Aviation Week & Space Technology

75 Cents

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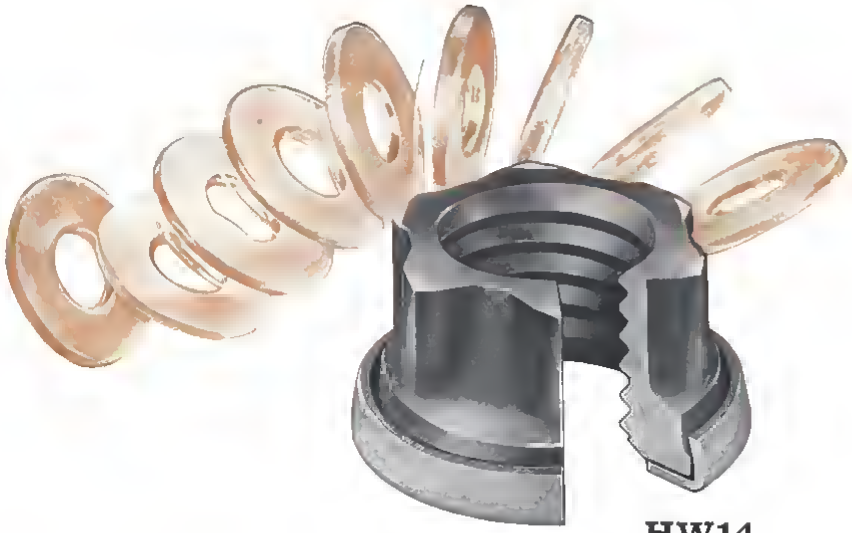
May 20, 1963

PHOTO REPORT:

USSR Missile Arsenal

F-4B Trails Soviet Bear During Carrier Overflight



HW14

Kaylock® 'captive washer' nuts cut costs-insure reliability!

Save the cost of buying, stocking, distributing and assembling separate washers. Do away with time lost looking for wayward washers. The Kaylock HW14 is a pre-assembled unit, a locknut with an integral free spinning washer which can't be lost during installation or removal. As there are no separate washers to fall into inaccessible places, this eliminates a cause of short circuits and malfunction of mechanisms.

The HW14 "captive washer" nuts employ Kaylock's patented elliptical MIL-N-25027 approved locking device ... the utmost in reliability. This combination washer-nut is a development of Kaynar Mfg. Co., Inc., world's oldest and largest manufacturer of lightweight all-metal self-locking nuts. Available in eight thread sizes, from #2-56 through ⅜-24, in steel for 500° applications or in A286 for 900° applications. Write today for the Kaylock HW14 brochure—or contact your Kaylock representative.

The Kaylock HW14 is available in size 02 (shown above) and in other sizes to -6

View of Kaylock HW14-3 and washer prior to assembly

Assembled HW14-3. Integral line to mount washer can't drop off. Only one part to handle prior to use.

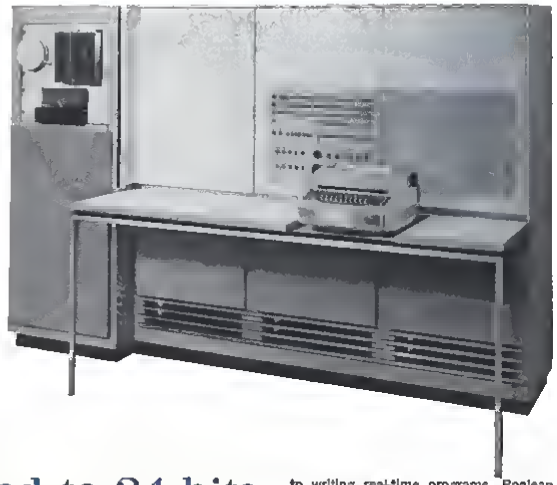
Kaylock®
first in lightweight locknuts

KAYNAR MFG. CO., INC., KAYLOCK DIVISION
Box 2001 Terminal Annex, Los Angeles 54, Calif. Branch offices warehouses & representatives in Wichita, Kan., New York, N.Y., Atlanta, Ga., Renton, Wash., Montreal, Paris, London, The Hague

$87,000

DDP-24 IS NOT designed to be all things to all people. DDP-24 IS a fast digital computer, versatile, a sophisticated "component" built to move in company with a precision team in complex real-time on-line configurations. Equally comfortable performing off-line engineering and scientific computations. Reliable? Very!

DDP-24 pays for itself on a diet of challenge. DDP-24 hardware, comprehensive software, user services and options belong in the hands of qualified professionals who know their applications and how to evaluate a computer against these selected applications. Under these conditions DDP-24's are a lot of computer for the money.



DDP expanded to 24 bits
Faster arithmetic unit
Comprehensive software

DDP-24 is a parallel 24-bit word, core memory, sign magnitude, binary, general purpose computer, with indexing and indirect addressing. Instruction repertoire includes multiply and divide, load and store, shifting, logical, jump, index, and input/output. Standard memory capacity is 4096 words (optionally expandable).

Simplicity, maintainability, user convenience are factors of design. Regulated power supplies and power failure protection preserve integrity of computation. Ready and interrupt modes give DDP-24 master or slave relationship with external equipment. Optional independent memory banks and fully buffered channels give true input-output, and compute overlap.

SPEED

Computation rate is 100,000 additions per second. Multiplication takes 31 microseconds, division 33 microseconds. Times include instruction and operand access. Other arithmetic speeds:

Add floating point	125μ/secs. max.
Multiply floating point	99μ/secs.
Add double precision fixed	55μ/secs.
Add double precision floating	181μ/secs.
Multiply double precision fixed	263μ/secs.
Multiply double precision floating	371μ/secs.

Core memory cycle time is five microseconds with three microsecond access. Input and output can occur asynchronously and be interleaved with processing at transfer rates up to 166,000 24-bit words per second.

INPUT-OUTPUT

Strong input-output capabilities enhance communication with surrounding equipment; offer unique freedom of system implementation. Standard DDP-24 incorporates an eight bit I/O character buffer register and channels, a 24-bit parallel input channel, a 24-bit parallel output channel, sixteen lines for external sense inputs, eight output control pulse lines, and four interrupt lines capable of asynchronous operation with the associated four basic input-output channels. Standard I/O equipment: typewriter, paper tape reader, punch.

SOFTWARE

Programming software provided with the DDP-24 is comprehensive, satisfying professional programmers writing complex routines, mathematical analysts and the occasional user. Fortran II, DAP, and DIP are modular, patterned after SHARE, easily adapted to specific hardware configurations. Diagnostics for rapid isolation of programming and system faults are included. Also provided: mathematical subroutines, number conversion, memory dump, library routines, master executive program, load program, and computer exercise routines.

Fortran II compiler permits investigation and development of math models prior to writing real-time programs. Boolean augmentation and macro calls are provided.

DAP — DDP-24 Assembler Program — with one-to-one and one-to-many assembly, facilitates tight real-time programs in convenient language.

DIP — DDP-24 Interpretive Program — permits users with minimum programming experience to generate scientific computation routines after only half a day's study.

OPTIONS

To offer still greater system adaptability and functional capabilities, extensive standard options and peripheral equipment are available for the DDP-24.

- ☐ core memory expansion to 16,384 words, with special expansion 32,768 words (directly addressable)
- ☐ additional index register ☐ word forming buffers ☐ character I/O buffer registers ☐ interrupt lines ☐ eight level hardware interrupt priority system ☐ additional sense lines ☐ output control pulses ☐ parallel I/O channels

I/O control units for maximized interlace and truly simultaneous operation:

- ☐ direct memory access control unit with unlimited channels ☐ fully buffered I/O control unit with unlimited channels.

Peripheral equipment optionally available: Magnetic tape control and transport units, A/D, D/A converters, card adapter, high speed line printer and adapter, digital plotter and adapter. Digital Resolver, satellite computer increases DDP speed up to 10 times for algebraic and trigonometric functions. Other peripheral requirements can be fulfilled. Write for the full story.

*Design is typical 3C. Modular construction is with S-PAC digital logic modules. Based upon a million PAC-hours of life test without failure the DDP-24 calculated MTBF is over 4000 hours.

COMPUTER CONTROL COMPANY, INC.

610 CONNECTICUT PATH · FRAMINGHAM, MASS. · 2251 BARRY AVENUE, LOS ANGELES 64, CALIF.

AEROSPACE CALENDAR

May 27-28—Seventh National Conference on Product Engineering & Production, Institute of Electrical and Electronics Engineers, Continental Hotel, Cambridge, Mass.

May 27-28—23rd National Meeting, Operations Research Society of America, Sheraton Hotel, Cleveland, Ohio.

May 27-29—17th Annual Frequency Control Symposium, Shelburne Hotel, Atlantic City, N.J. Sponsor: U.S. Army Electronics Research & Development Laboratory.

June 2-14—Third Annual Reliability Institute, University of Connecticut, Storrs, Conn.

June 3-5—Symposium on Materials and Processes for Space Power and Primary Propulsion, Society of Aerospace Material and Process Engineers, Bellevue-Stratford Hotel, Philadelphia, Pa.

June 3-5—Spring Lubrication Symposium, American Society of Mechanical Engineers, Hotel Somerset, Boston, Mass.

June 3-11—COSPAR Fourth International Space Science Symposium and Sixth Plenary Meeting, Warsaw, Poland.

June 4-6—17th Annual Convention and Exhibition, Armed Forces Communications & Electronics Assn., Sheraton Park Hotel, Washington, D.C.

June 4-6—Ninth Annual Radar Symposium, (Secret), conducted by the University of Michigan at Fort Monmouth, N.J. Sponsors: USA, USN, USAF.

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AEROSPACE CALENDAR

(Continued from page 5)

June 4-6—National Electronic Packaging and Production Conference, Coliseum New York, N Y

June 6 7—Symposium on the Exploration of Mars Denver Hilton Hotel Denver Colo Sponsor American Astronautical Society Co-sponsors American Astronomical Society American Institute of Biological Sciences, AIAA Rocky Mountain Sections, NASA

June 7-8—14th National Maintenance & Operations Meeting, Reading Aviation Service, Reading Pa

June 7-16—25th French International Air Show Le Bourget Paris, France

June 10 28—Symposium on Lubrication and Wear, University of Houston For information Dr D Muster Dept of Mechanical Engineering University of Houston Houston 4, Tex

June 11 14—Symposium on Plasma Space Science, The Catholic University of America, Washington, D C, with the support of NASA and Goddard Space Flight Center

June 12 14—Heat Transfer and Fluid Mechanics Institute, American Institute of Aeronautics and Astronautics, California Institute of Technology, Pasadena

June 13-15—Great Lakes Navy Research and Development Clinic Ohio State University Columbus Ohio conducted by the Office of Naval Material

June 17 20—Summer Meeting, American Institute of Aeronautics and Astronautics (AIAA), Hotel Ambassador, Los Angeles

June 17 21—Summer General Meeting Institute of Electrical and Electronics Engineers Toronto, Canada

June 18 20—41st Meeting Aviation Distributors and Manufacturers Assn., Chateau Frontenac Quebec Canada

June 19 21—Fourth Joint Automatic Control Conference University of Minnesota, Minneapolis, Minn Sponsors American Institute of Chemical Engineers Institute of Electrical and Electronic Engineers, American Society of Mechanical Engineers Instrument Society of America

June 23 28—66th Annual Meeting American Society for Testing and Materials, Chalfonte Haddon Hall, Atlantic City

June 26 27—10th Annual Symposium on Computers and Data Processing University of Denver's Denver Research Institute Elkhorn Lodge Estes Park Colo

June 26-27—Symposium on Dynamic Load Problems—Helicopters and V/STOL, Statler Hilton Hotel Buffalo, N Y Sponsors Cornell Aeronautical Laboratory; Army Transportation Corp

June 28-July 3—Second Annual Dorado Fly-In, Dorado Beach Hotel, Dorado P R.

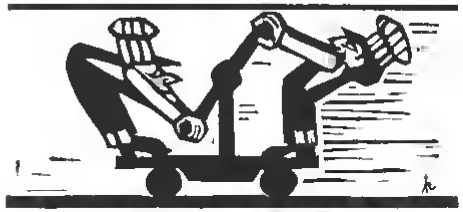
July 7-11—Seventh National Conference on Aerospace Education, National Aerospace Education Council, Hotel Deauville, Miami Beach Fla

July 9 11—International Symposium on Space Telecommunications Institute of Electrical and Electronic Engineers' Professional Group on Antennas and Propagation Boulder Laboratories Boulder Colo

July 10 12—Meteorological Support for Aerospace Testing and Operation American Institute of Aeronautics and Astro

(Continued on page 9)

PROBLEMATICAL RECREATIONS 171



The consumption of coal by a locomotive varies as the square of the speed. Other operating expenses (exclusive of coal) are $72 per hour. If the price of coal is $10 per ton and at a speed of 25 mi/hr the locomotive uses 5 tons per hour, what is the minimum cost of a trip of 100 miles? —*Contributed*

ANSWER TO LAST WEEK'S PROBLEM: Each is making $\frac{11}{10} \cdot \frac{9}{10} = \frac{99}{100}$ times the original salary.

AEROSPACE CALENDAR

(Continued from page 7)

nautics and American Meteorological Society, Ft. Collins, Colo.

July 23-26—Torpedo Propulsion Conference (Confidential) American Institute of Aeronautics and Astronautics U.S. Naval Underwater Ordnance Laboratory, Newport, R.I.

July 25-27—1963 Microminiaturization Congress American Institute for Microminiaturization Sheraton Park Hotel Washington, D.C.

Aug. 4-9—International Conference and Exhibit on Aerospace Support Institute of Electrical and Electronics Engineers/American Society of Mechanical Engineers Park Sheraton Hotel Washington.

Aug. 12-14—Guidance and Control Conference American Institute of Aeronautics and Astronautics Massachusetts Institute of Technology Cambridge, Mass.

Aug. 19-21 — Astrodynamics Conference, American Institute of Aeronautics and Astronautics Yale University New Haven.

Aug. 20-23—1963 Western Electronic Show and Convention (WESCON) Cow Palace San Francisco, Calif.

Aug. 26-28—Simulation for Aerospace Flight Conference American Institute of Aeronautics and Astronautics Deshler-Hilton Hotel Columbus, Ohio.

Aug. 26-28—Conference on Physics of Entry into Planetary Atmospheres American Institute of Aeronautics and Astronautics Massachusetts Institute of Technology Cambridge, Mass.

Sept. 8-11—International Symposium on High Temperature Technology Asilomar, Calif. Sponsor Stanford Research Institute.

Sept. 8-11—Annual Meeting Air Industries Assn. of Canada Manoir Richelieu Murray Bay, Quebec.

Sept. 9-11—Seventh National Convention on Military Electronics. Institute of Electrical and Electronics Engineers Shoreham Hotel Washington, D.C.

Sept. 9-12—18th Annual Instrument Automation Conference & Exhibit, Instrument Society of America McCormick Place, Chicago, Ill.

Sept. 10-12—National Symposium on Space Rendezvous Rescue and Recovery Edwards AFB, Calif. Sponsors American Astronautical Society, Air Force Flight Test Center.

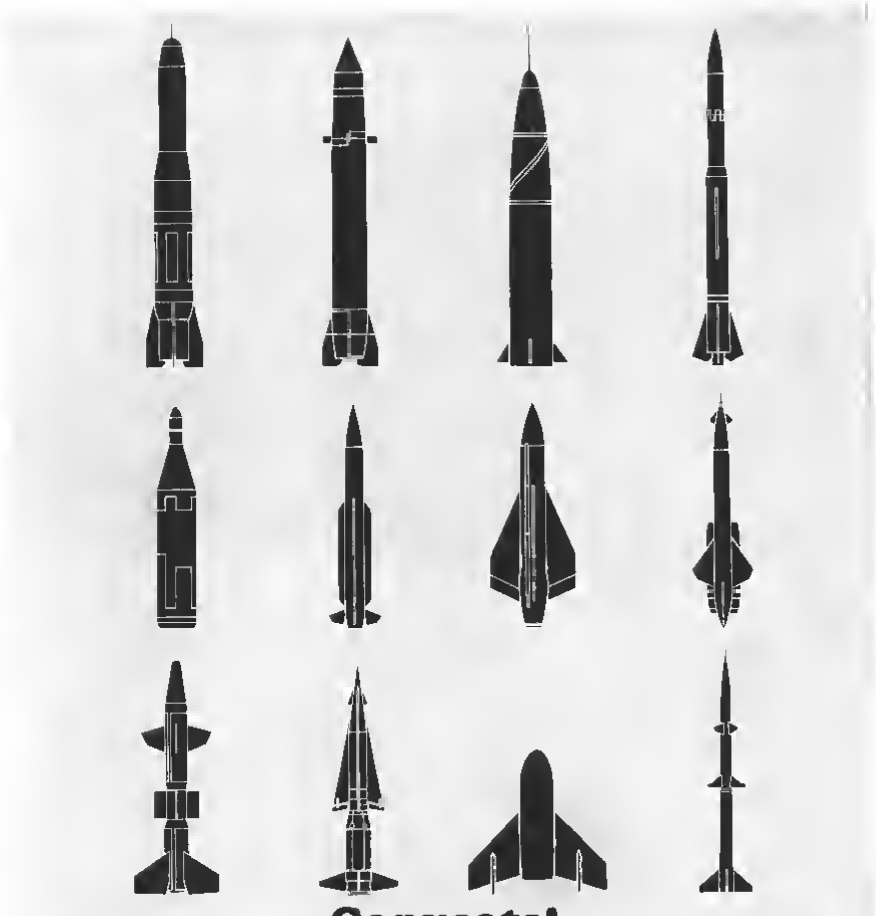
Sept. 16-18—International Aviation Research and Development Symposium Atlantic City, N.J. Sponsor Federal Aviation Agency.

Sept. 18-19—1963 Artwork Operations and Maintenance Symposium Millville, N.J.

Sept. 23-27 — International Telemetering Conference, Savoy Place London, England Sponsors Institution of Electrical Engineers (London), American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers Instrument Society of America.

Sept. 25-26—Second Annual Symposium on the Physics of Failure in Electronics Chicago, Ill. Sponsors Rome Air Development Center, Armour Research Foundation.

Sept. 26-Oct. 1—14th Congress, International Astronautical Federation, Paris, France.



Copycats!

(they all rely on Sonotone batteries)

When millions of dollars depend on batteries, decisions must be made with exacting care. That's why design engineers in most U.S. missile, rocket and satellite development programs depend on Sonotone rechargeable sintered-plate, nickel-cadmium cells and batteries to do the jobs where reliability counts most.

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When specifications call for facilities capable of performance parameters never before attained, and, in addition, capacity for future updatings, it is logical to look for a supplier with a successful background of accomplishment in this specific area.

Stokes designed and built the first Goddard space chamber, NASA's "8 by 8." This thermal-vacuum chamber, capable of a simulated 200-mile altitude, is still in full-time use for satellite systems check-out prior to launch. Other important Stokes first-of-a-kind facilities:

G. E. Missile and Space Division: Four 5′ x 5′ component testing chambers regularly attaining vacuums in the 10^{-9} Torr range, using 20°K cryopumping.

G. E. Missile and Space Division: Three 39′ diameter spherical chambers, utilizing the dense gas helium cryopumping techniques proved in the 5′ x 5′ chambers. These large units (one of them is shown above) reached 10^{-10} Torr during initial operation.

Bell Telephone Laboratories: 9′ diameter, 13′ long environmental-simulation chamber with liquid nitrogen cooled shroud. 10^{-8} Torr has been demonstrated.

NASA, Goddard Space Flight Center: Vacuum and cryogenic systems for two chambers, 35′ in diameter and 60′ high. These SES and DTC facilities are used for proof-testing complete advanced NASA space vehicles and probes. SES chamber cryopumped to 10^{-10} Torr during acceptance tests.

Douglas Aircraft Corporation: Three earth-orbit simulators, the largest a 39′ sphere, for testing spacecraft scheduled for manned flight. (In construction.)

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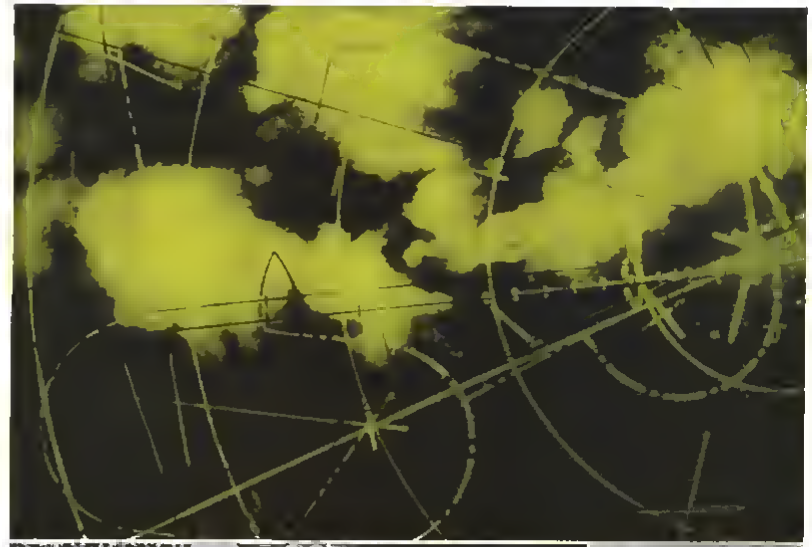

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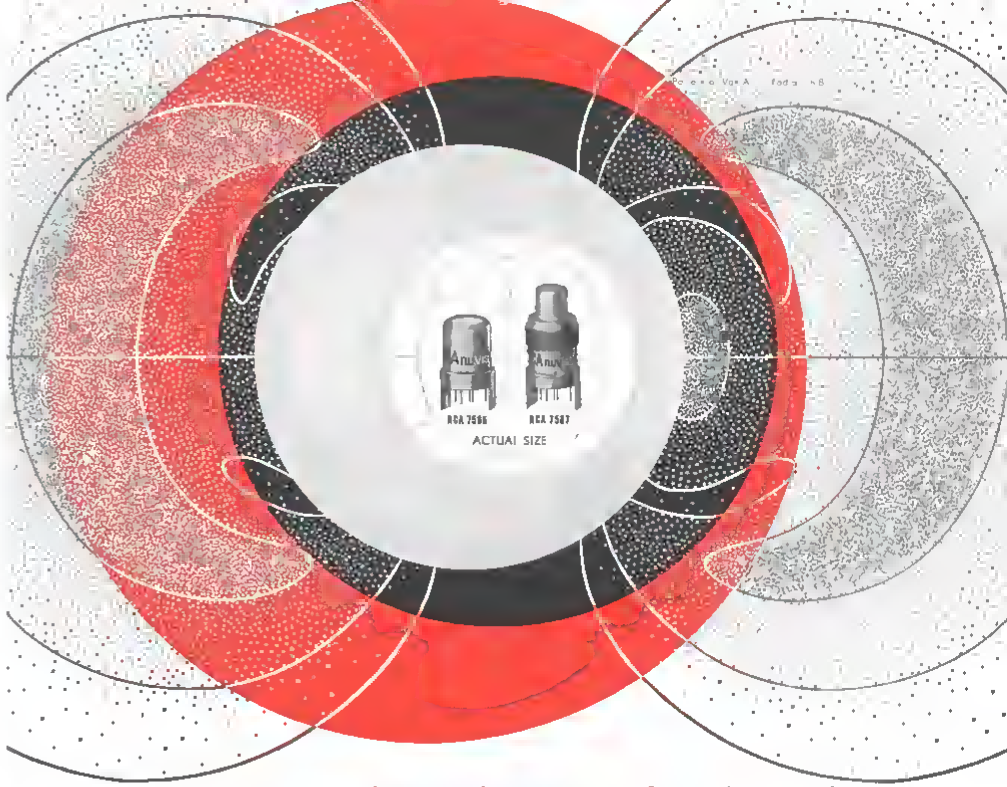

For electronic equipment that must perform dependably in the presence of nuclear radiation fields

SPECIFY RCA NUVISTORS

The RCA nuvistor is in the class of active electronic-circuit components least susceptible to catastrophic failure from nuclear radiation.

Tests have demonstrated the rapid recovery and dependable performance of the RCA-7586 triode and the RCA-7587 tetrode after these nuvistors were subjected to both pulse and steady state nuclear radiation as specified in the Neutron Radiation Damage Test, Military Standard MIL STD 446A, November 25, 1960.

Specific test exposure levels and results for commercially available nuvistors are:

Pulse Nuclear Radiation. Nuvistor types 7586 and 7587 were operated in a 15-kc amplifier circuit and monitored during exposure to pulse nuclear radiation under the following conditions: neutron flux intensity, $\cong 10^{16}$ neutrons per square centimeter per second; energy level, $\cong 2.5$ million electron volts; pulse duration, 65 microseconds; integrated total neutron flux, 2×10^{12} neutrons per square centimeter. In both the 7586 and 7587, recovery of the output signal was achieved in less than 0.5 millisecond after the end of the radiation pulse.

Steady-State Nuclear Radiation. Samples of the 7586 nuvistor tube were exposed to steady state nuclear radiation under the following conditions: neutron flux intensity, $\cong 10^{12}$ neutrons per square centimeter per second; energy level, $\cong 1$ million electron volts; integrated total neutron flux, 10.8×10^{14} neutrons per square centimeter. After exposure, all of the 7586 nuvistor tubes remained operable and exhibited an average change in transconductance of less than one percent compared to the initial reading.

These facts, plus the already established advantages of nuvistor, are of vital importance to the designer of electronic equipment for use in the presence of nuclear radiation fields.

Whatever your specialty in the field of electronics, it will be to your advantage to know more about nuvistors. Call the RCA Electron Tube Division Field Office nearest you for information on specific nuvistor types or write Commercial Engineering, Section **8-112-06-3**, RCA Electron Tube Division, Harrison, N. J.

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From Fafnir –

computer-programmed bearing reliability for turbine-powered helicopters

Time was when helicopter transmission bearings could be selected right from the catalogs. But no more. In turbine-powered 'copters, especially, many gearbox bearings must be custom-engineered

Fafnir is a major supplier of such bearings — and the leader in applying advanced computer techniques to bearing engineering. The gearbox bearings shown above are good examples.

The application demanded extremely rigid shaft support and high running accuracies under conditions of severe vibration. Bearing load capacity, weight, and size were critical, too

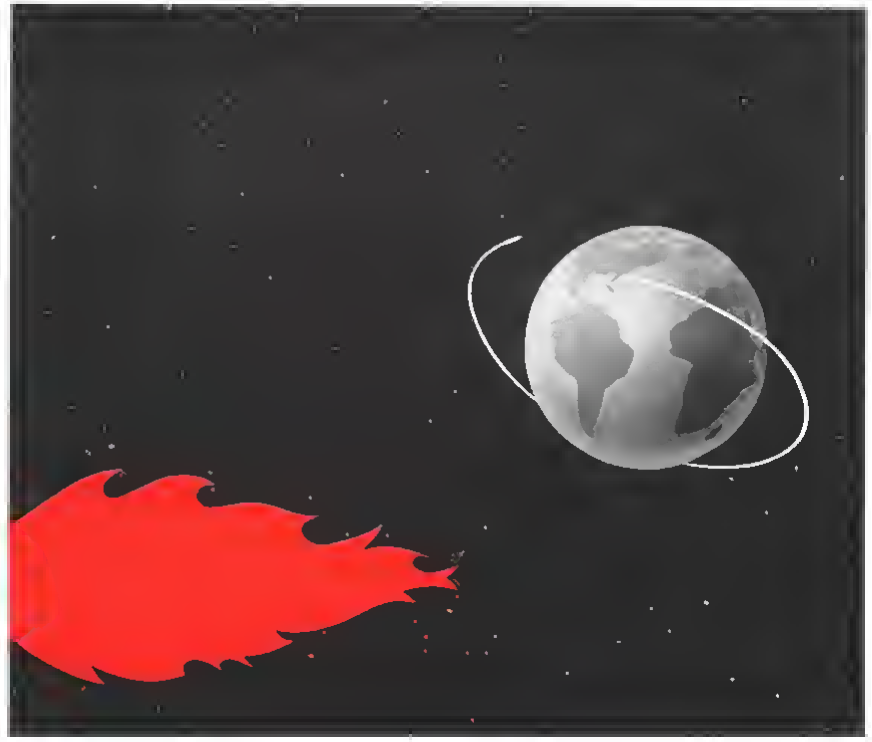
An IBM 7090 computer analysis helped Fafnir engineers explore design alternatives and determine optimum bearing characteristics. Result: a duplex set of angular contact bearings precisely engineered for maximum performance and load-life requirements

Chances are, the "computer approach" at Fafnir can help you meet critical needs precisely . . . and with utmost reliability. Investigate. Remember: "Fafnir" on your bearings assures sound engineering . . . highest quality . . . full value at a fair price. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

FAFNIR DUPLEX BEARING SET FOR HELICOPTER GEARBOX

Flanged WI type bearing with companion WO type bearing, manufactured to ABEC-7 limits. Rings and balls of high-strength vacuum-melt M-50 steel made by consumable electrode process are 100% magnetic particle and surface temper inspected. Machined bronze retainers are 100% fluorescent penetrant inspected.



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FLAME-PLATING: TOMORROW'S COATINGS . . . FOR TODAY'S WEAR PROBLEMS

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Aviation Week & Space Technology

Volume 78
Number 20

May 20, 1963

CONTENTS

COVER Navy/McDonnell F-4B Phantom 2 jet, armed with Raytheon Sparrow 3 air-to-air missiles is shown trailing one of the four Soviet Tu-95 Bear bombers which made nine passes over the U S Navy carrier Constellation 600 mi south of Midway Island on Mar. 16 (AW Mar 25 p 22) The Russian aircraft were carrying out electronic ferreting missions Bear turboprop bombers made two passes at 24,000 ft and seven at less than 3 000 ft

PICTURE CREDITS

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EDITORIAL

Press On!!

The 22 orbit space flight of Air Force Maj. Gordon Cooper in Faith 7 marks a significant change in the character of the U.S. manned space flight program. With this historic 34-hr. mission, Project Mercury has emerged from its experimental flight test program to the beginning of an operational capability that hopefully will come to fruition in the Gemini and Apollo missions. The hallmark of "routine" was stamped on Maj. Cooper's flight from the practically perfect launch of the Atlas 130 D booster to the precisely executed recovery. This may have disappointed daily newspapers with its paucity of exciting headlines, but it was a tremendous thrill for everybody who has worked on manned space flight. This uniform precision provided the genuine technical impact of Faith 7's performance as a major milestone in man's march toward the stars.

The flight of Faith 7 and its laconic pilot demonstrated a sustained precision in its round-the-clock operations that gives more of an inkling of what lies ahead in manned space flight than did the initial experimental flights of Astronauts Shepard, Grissom, Glenn, Carpenter and Schirra—although the last provided the first faint glimmering of this future for those sufficiently perceptive to understand.

It is an inevitable historic trend that as new technology is transformed from the spectacular experimental stage to reliable operational use, peripheral public interest lags almost in proportion to the increase in technical significance. For example, the world press could write about little else for months after Charles Lindbergh made the first solo transatlantic aircraft flight from New York to Paris just 36 years ago this month. Last year more than two million people followed his trail across the transatlantic airway—most of them in jet transports taking about one-fourth the time of Lindbergh's flight. Yet only a few obscure statistical paragraphs in the daily press recorded this tremendously significant perspective on the trail Lindbergh blazed.

Mercury's Solid Foundation

And so it is likely to be with manned space flight as it passes from the experimental flight test phase into reliable operational performance. The relaxed and skillful piloting of Maj. Cooper in a well-proved McDonnell spacecraft, supported by an incredibly efficient earth-based tracking, communications and control system on a continuous schedule with round-the-world capability is less exciting than the first breathless attempt of man simply to survive short duration space flight. But it is the type of foundation on which future capability can be built solidly.

Whether or not there is an MA-10 flight (AW May 13, p. 34), the flight of Faith 7 marks the fulfillment of the original Project Mercury technical goals with sufficient excess performance to write a fine, flourishing finish to this program. Mercury is a superb example of what America's technology can accomplish when it is given a clear goal and sustained support over the required time scale.

Mercury must go down in history as one of the most successful technical programs this nation has ever had.

Its managers and operators—Bob Gilruth, Walt Williams, Ken Kleinknecht, Max Faget, Chris Kraft, George Low and their cohorts—its pilots and the personnel of the global tracking and communications network organized by Goddard Space Flight Center—all deserve an accolade. Never has a national technical program been better supported by the aerospace industrial contractors who produced its hardware. Nor was there any stinting in support for NASA on this project by other government agencies, such as the Air Force with its missile test range and biomedical capability, the Navy with its recovery forces, and the Weather Bureau.

The Only Flaw

The only flaw in the Mercury history, and this is certainly no fault of anybody in the program, is that it was not a pioneering effort in which this nation led the world and truly opened man's eyes to the universe around him. It is a sad historic fact that this nation was pushed into space by the Soviet Union—a country that we had mistakenly regarded as too backward to compete in modern technology. The Soviet Union put the first man into orbital flight. It has continued with a hard driving program that has leaped forward in technical increments of surprising magnitude. Without question, Russia still is the world leader in manned space flight operations with the 1962 performance of its space twins, Maj. Nikolayev and Col. Popovich, and their simultaneous three- and four-day orbital flights.

However, without Mercury and the dogged stern chase its men have been waging with the Soviets for the past five years, this nation would be hopelessly outclassed in space technology instead of now pulling into a position to challenge the Russians seriously for the first manned lunar landing. It is interesting to note that only the achievement of the Soviet space twins surpasses Maj. Cooper's 34-hr. space flight in which he exceeded Soviet Cosmonaut Titov's performance by some five orbits and 10 hr.

Mercury's achievement has laid a solid foundation for the U.S. manned space flight program. The more challenging and complex tasks of Gemini and Apollo lie immediately ahead. The message of the Mercury performance should ring out clearly to the American people—Press On!!

—Robert Hotz

WHO'S WHERE

In the Front Office

Grumman Aircraft Engineering Corp., Bethpage N Y has appointed the following corporate officers as senior vice presidents **Llewellyn J Evans, Richard Hutton,** and **George Titterton** The following executives were appointed vice presidents **Ira Grant Hedrick, A James Zisi** and **J B Rettaliata**

Leonard J Heilman president, General Technology Corp., Torrance, Calif

Paul M Kuefler, president, Gemisco, Inc Los Angeles Calif., succeeding **E C Burkhart,** who continues as board chairman Also **John F Harrison,** president Eldema Corp., a Gemisco subsidiary

George E. Johnson chairman Houston Fearless Corp., Beverly Hills Calif., succeeding **Noah Dietrich Fred C Mehner** succeeds Mr Johnson as president and chief executive officer

Col Donald A Olson (USAF ret.) assistant for administration to the president of the Aerospace Group General Precision, Inc Little Falls, N J

Capt Fred W Kittler (USN ret.) technical assistant to the president of TRG Inc and head of the new Washington (D C) Office

Robert F. Gabarini, chief engineer of the Air Armament Division of Sperry gyroscope Co will become director of the National Aeronautics and Space Administration's Office of Application as of **July 1,** succeeding **Morton J Stoller,** who becomes deputy to Mr Gabarini and special assistant to James E Webb, NASA administrator

Honors and Elections

Pan American Grace Airways, Inc. has received the Ghilean Air Forces Will of Flight Trophy in recognition of the airline's valuable contribution to Chile's aviation and to the development of air travel between the United States and South America

Changes

Col Telford S Byington, chief, Reconnaissance Div., Air Force Avionics Laboratory Aeronautical Systems Division (ASD) Air Force Systems Command, Wright-Patterson AFB Ohio succeeding **Col Roger K Rhodarmer,** now chief of the Reconnaissance System Program Office ASD

Col Paul S Bechtel (USAF ret.), former chief of the Ballistic Missile Defense Div Headquarters NORAD, is now special projects manager for the executive vice president Western Electrodynamics Inc, Colorado Springs Colo

Col Frank M Townsend, vice commander, Aerospace Medical Division, Brooks AFB Tex replacing **Col Robert H Blount,** now senior USAF medical representative to Supreme Headquarters Allied Powers in Europe (SHAPE) Paris France Also **Lt. Col Stanley C White,** former chief of the National Aeronautics and Space Administration Manned Spacecraft Center's Crew Systems Div., will report to the Aerospace Medical Div., Brooks AFB in July for duty with the deputy chief of staff for Research and Development

(Continued on page 142)

INDUSTRY OBSERVER

► Operational tests of Goodyear Subroc system, delayed when the first system was lost aboard the Thresher, are scheduled to begin soon Weapon is launched like a torpedo, after clearing the tube, its solid-propellant rocket motor ignites and Subroc flies out of the water Inertial guidance directs it toward the enemy submarine target Thrust reversal is programed to separate warhead from body, warhead coasts to target in free flight

► Sprint anti-missile missile, under development by Martin-Orlando for Army Missile Command, is to use all-movable fins instead of trailing-edge control surfaces. Method shows both weight and hinge-moment reductions, but increases thermal problems Army may supply propulsion system for Sprint as government-furnished item

► Vela Hotel nuclear blast-detection satellite is planned for operational lifetime up to three years Two of the satellites will be detached from Agena D spacecraft successively for dispersion in a circular orbit of approximately 40,000 naut mi altitude Orbit should be attained at apogee of transfer orbit from parking orbit Altitude will keep the satellite out of perturbing effects of earth's magnetic field Six of the satellites are estimated as necessary to give sufficient backup to ensure global coverage.

► Some British observers of the Anglo-French supersonic transport program believe the French are using the project to increase their own technology in areas where the British already have capability, experience and facilities One example cited is airborne radar, Sud Aviation is expanding its effort in this field although Britain already has extensive capability.

► NASA/McDonnell Gemini two man space capsule will have a total velocity capability of about 700 ft /sec from its on-board propulsion system (AW May 13, p 53) Capability could be increased to 2,500 ft./sec depending on the amount of residual propellant in the Lockheed Agena stage after rendezvous and docking of the capsule with that stage

► Industry proposals for payloads suitable to fly piggyback on Block 4 Ranger lunar spacecraft (RA10-12) and to be principal payloads for Block 5 Rangers (RA13 and beyond) are being reviewed by NASA headquarters. Block 5 spacecraft are expected to have hard-landed survivable capsules of the type employed in Rangers 3 through 5 Each Block 4 spacecraft, the first of which is to be launched this year, will carry as its main payload a package of six vidicon cameras for lunar closeups prior to spacecraft impact.

► Ground-based non-nuclear satellite interception and disabling system techniques are to be studied during the next six months for Advanced Research Projects Agency by Boeing, Hughes, Ling-Temco-Vought, RCA and Space Technology Laboratories Series of ARPA studies on space-based intercept and nuclear-kill system techniques is expected to follow

► Site near Woomera, Australia, may be one of the two landing areas for the Apollo capsule after its return from a lunar-landing mission Other site considered is in the southwestern United States

► Unresolved differences among military services has delayed issuing a standardized designation list of missiles similar to the one issued for aircraft last year Office of the Air Force Deputy Chief of Staff for Systems and Logistics is coordinating the project

► Navy will convert all North American A-5A and A-5B Vigilante carrier attack bombers into the A-5C reconnaissance version About 55 aircraft will be affected. Difficulties with bomb ejection system were partly responsible for the decision

► Royal Air Force may retrofit its Avro Shackleton maritime-reconnaissance piston-engine bombers with additional powerplants—two Bristol Siddeley Viper turbojets—to give the long-range airplane more loiter capability If approved, retrofit would extend Shackleton capability pending completion of new requirement for an all-jet replacement aircraft (AW Mar 11, p 275)

Washington Roundup

Save-the-RS-70 Drive

North American is trying to save the RS-70 program by offering to fly the first prototype as early as August, rather than wait until next year so all the minor structural problems can be corrected. But it is not certain whether Air Force Secretary Eugene Zuckert, who favors the RS-70 project, will get any encouragement for an early test flight from Defense Secretary Robert McNamara, who opposes it (AW May 13, p. 25).

Prospect of the RS-70 being killed deeply concerns congressional leaders who already feel the Kennedy Administration is placing too much reliance on ICBMs. Most of them are reserving comment until they hear from McNamara directly on the RS-70's future, but Rep. Gerald Ford, Jr., ranking Republican on the House Defense Appropriations Subcommittee, said it "would be a breach of faith with Congress" for McNamara to do less than fully test the three RS-70s already authorized.

NASA Budget Push

Afterglow from Astronaut Gordon Cooper's successful flight (see p. 26) probably will not last long enough to soften congressional critics of the space agency's $5.7-billion Fiscal 1964 budget. The earliest the first budget bill can reach the House floor is June, because of space committee work still to be done.

NASA Administrator James Webb is combating skeptics by arguing the space program is building the foundation for continued U.S. leadership of the world (AW May 13, p. 25). He told the Second National Flight Forum Symposium at Hartford, Conn., that: "Those who view the lunar program simply as a propaganda effort fail to grasp that not only our prestige, but our capacity for constructive international leadership, our economic and military capacity for technological improvement, depend upon our ability to achieve acknowledged superiority in science and technology, and to use this capability in our own behalf and that of our allies."

House Government Information Subcommittee this week will challenge the National Aeronautics and Space Administration's handling of the Satellite Situation Report. Subcommittee wants to know why the amount of information released varies from report to report and why Russian space failures are not disclosed. George Simpson, NASA assistant administrator in charge of the report, is to testify May 21.

TFX Flying Competition

Chairman John McClellan of the Senate subcommittee investigating the F-111 (TFX) contract award is still convinced that an actual flying competition between rival prototypes is the best way for the government to select an aircraft.

He said General Dynamics' arguments against such a competition failed to persuade him otherwise (AW May 13, p. 27). Sen. McClellan emphasized this did not necessarily mean he will recommend a flying competition between General Dynamics and Boeing to determine which has the better F-111. But he feels that requiring such actual competition in the future would assure the taxpayers of getting the most weapon for their dollar.

Although the Rand Corp. report on prototype competition (AW Apr. 22, p. 31) was placed in the hearing record, the authors themselves were not called to testify because they do not believe their findings apply to the F-111 case.

GOPs Bug Grumman

Grumman Aircraft, associated with General Dynamics in the politically-heated TFX project, has drawn some political fire on its own. Four New York Republican Congressmen have accused the company of pressuring subcontractors to contribute to the Nassau Democratic County Committee.

J. B. Rettaliata, Grumman vice president, sent letters on company stationery to subcontractors and others declaring: "It is our hope that you will join with other interested and responsible people concerned with good county government and take a full page ad in the journal" for the county committee's annual dinner June 1. Full page ads ran as high as $3,000. Rettaliata, a registered Republican, said no one else at Grumman knew anything about the letters. He said he wanted to promote two-party government in Nassau County, adding: "I should not have used any title as a corporate officer or company letterhead for this purpose." Grumman President E. Clinton Towl disavowed the letter and said he was "shocked" it was sent.

Reps. Frank Becker, Steven Derounian, James R. Grover and John Wydler said that the letter gave assurance that contributing to the county committee would fulfill obligations to the National Democratic Committee. They said the letter was "another example of pressure being exerted by the Kennedy Administration on small businessmen who depend on defense contracts."

Army Secretary Cyrus Vance deepened Air Force fears about Army aviation ambitions by declaring last week that turning to aircraft "is as inevitable as the turn from the horse to the truck." He predicted "air mobility may ultimately produce a tactical revolution as profound as the initial mechanization of land warfare."

Pacific Missile Range officials could sympathize with their Atlantic counterparts when such an everyday item as a diesel engine caused a hold in the first MA-9 countdown last week. Navy has asked industry to develop a "railroad train sensing and position indicating system" for PMR. The device would warn of approaching Southern Pacific trains so Pt. Arguello and Vandenberg AFB range safety officers could halt missile countdowns until the trains had rumbled through the range. —Washington Staff

MERCURY ATLAS-9 lifted off Pad 14 at Cape Canaveral at 9:04 a.m. EDT May 15. USAF/Martin Titan 1 is at left, Titan 2 (center).

Cooper Flies Almost-Perfect 22 Orbits

Cape Canaveral—Longest and most precise U.S. manned space flight ended successfully May 16 when Maj. Gordon Cooper landed his Faith 7 Mercury capsule 7,000 yards from the prime recovery ship 34 hr. 20 min. 20 sec. after launch, despite potentially hazardous component failures that developed on the last four orbits of the 22 orbit mission.

Cooper, the fourth U.S. astronaut to fly an orbital mission, was forced to bypass the automatic attitude control system and to fly the capsule manually through the entire re-entry sequence. He used fly-by-wire from the time he positioned Faith 7 for re-entry until his main recovery parachute deployed at about 10,000 ft. above the Pacific near Midway Island.

He was lifted to the deck of the carrier Kearsarge by crane at 8 p.m. EDT, 36 min. after he landed at 7:24 p.m.

He blew the hatch of his capsule at 8:05 p.m. and physicians on the carrier who examined him then said he was in good condition.

Cooper's flight had been normal to the point of being routine through 19 orbits. As he was completing the 19th he reported to the Hawaiian tracking station that his 0.05g indicator light came on when he dimmed the lights on his instrument panel. The indicator light is a critical part of the automatic sequencer, and it normally illuminates only after retro-fire, as re-entry gravity forces begin to build.

At first it was believed that the indicator had lighted because of a faulty circuit. But tests performed by Cooper and analysis on the ground raised the fear that the automatic sequencer might be inoperative in the vital retro-sequence (retro-attitude, retro-fire and retro-jettison steps). This meant that Cooper would have had to perform these functions manually.

From the time the indicator light trouble became apparent, Mercury Control here was in almost-constant communication with Cooper, directly or through other tracking stations, in an attempt to diagnose the extent of the problem and to give him alternatives.

MA-9 Coverage

Special four-man editorial team provided on-the-spot coverage of MA-9 from Cape Canaveral for Aviation Week & Space Technology readers. They were Editor Robert Hotz, Washington Bureau Chief Evert Clark, Space Technology Editor Edward H. Kolcum and Cape Canaveral Bureau Chief George Alexander.

Finally it was decided that he would perform all the steps up to and including retro-fire manually, and then let the capsule go on automatic control. However, during the final orbit, the possibility of using the automatic system to damp re-entry oscillations was eliminated because both primary and standby inverters for the automatic attitude control system failed to start.

As Cooper came within range of the Pacific tracking ship Coastal Sentry off Japan, Astronaut John Glenn went through the final checklist with him by radio and both astronauts chanted the countdown in unison for both the retro-sequence and manual retro-fire.

Precision with which Cooper performed his maneuvers was demonstrated by his positioning of the capsule for retro-fire, which Glenn said was perfect, by his firing of the retro-rockets at exactly the programed time, and by his controlling of the capsule precisely after retro-fire. The expected communications blackout caused by the re-entry plasma sheath occurred within 2 sec. of pre-flight prediction.

Cooper did such an excellent job of reaction control fuel management that on the 21st orbit he reported to Glenn that 60% of his automatic and 76% of his manual fuel remained. Cooper's descent trajectory allowed him to maintain continuous communication with Astronaut Scott Carpenter, capsule communicator in Hawaii, from the end of the blackout until a few moments before landing.

As Cooper was preparing for his retro-sequence, Glenn told him he had "a dealer's choice" of two manual systems—fly-by-wire or manual proportional—for the re-entry sequence. Cooper selected fly-by-wire.

The extraordinary success of Cooper's flight was expected to play a strong part in determining whether another Mercury flight, MA-10, will be scheduled. National Aeronautics and Space Administration is considering a 72-hr. flight in September, but will not make a decision on it until the full impact of Cooper's mission has been evaluated. This is expected to take about four weeks (AW May 13, p. 34).

Brainerd Holmes, NASA director of manned space flight, said several times here while Cooper was in orbit that MA-10 will not be flown unless it adds enough to be worth its cost of $8-$10 million, nor would it be flown if "we got all the information we wanted from MA-9."

Maj. Cooper was launched from Pad 14 here in his Faith 7 capsule at 9:04 a.m. EDT May 15 by General Dynamics/Astronautics Atlas 130-D, which had the most accurate cutoff conditions of any Atlas vehicle used to carry a Mercury payload (see box, p. 29). His capsule was McDonnell production spacecraft No. 20, which was injected into orbit with a perigee of 100.2 stat. mi., an apogee of 165.8 stat. mi. and a period of 88.6 min.

MA-9 injection velocity was 17,546 mph. Inclination to the equator was 32.5 deg.

Major concern during the first minutes of the flight stemmed from excessively high telemetry readings of both suit and cabin temperatures. There was no cabin cooling between liftoff and the time the capsule reached an altitude of about 50,000 ft. An expected thermal lag resulted while Cooper determined the proper setting to control the amount of water coolant flowing through the heat exchanger.

Readings shortly after launch indicated that the suit temperature was 92F and that the cabin had reached as high as 118F. Although the pilot said that he felt "slightly warmer than normal," the suit reading apparently was erroneous. During the second orbit, suit temperature readings had stabilized at 60F and the cabin at 100F.

System temperatures became a concern after Lt. Cdr. Scott Carpenter experienced difficulty in finding the proper adjustment for the suit cooling system during his MA-7 flight last May (AW May 28, p. 26).

Both Carpenter and Marine Lt. Col. John Glenn, the first U.S. orbital pilot in MA-6, virtually expended their hydrogen peroxide reaction control fuel in their three-orbit flights. Cooper was programed to drift intermittently throughout his mission to conserve fuel.

At the conclusion of the first orbit, Cooper reported that his automatic fuel indicator showed 101% and his manual tanks 102%. After the second orbit, the readings were 92% automatic and 96% manual fuel remaining.

Series of physiological readings were made during the second orbit and showed Cooper's pulse had stabilized at 80-86 beats/min. after a peak of 150 during powered flight; his body temperature was 98.5, blood pressure 120/80, and respiration 12-20 breaths/min. Cooper urinated during the orbit as part of a study of his water balance and kidney function during weightless flight.

Cooper deployed a flashing light

Launch Delay

Cape Canaveral—Diesel engine and an analog-to-digital converter caused a one-day delay in the MA-9 flight of Maj. Gordon Cooper here last week. Cooper was originally scheduled to be launched between 9 and 11:30 a.m. EDT May 14.

Count proceeded smoothly on May 14 until about T —60 min., when the gantry was to have been rolled back. One of two diesel engines at the base of the gantry would not start.

At first, it was thought that the engine fuel was contaminated. However, after draining, purging and re-filling the fuel system with new fuel, the engine still would not start. The trouble finally was pinpointed as a faulty fuel pump.

Unit was replaced and the count resumed at 10:09 a.m. EDT and proceeded until T —13 min. when the tracking station at Bermuda reported that it could not proceed further.

Trouble stemmed from the analog-digital converter which translates the analog signals off the FPS/16 radar dish into 21-bit digital words. Bermuda found that the converter began dropping about 2% of the bits at about 7 a.m. EDT, but this grew steadily worse to about 14%. A decision was made to cancel the flight at 10:57 a.m. EDT until the converter could be repaired.

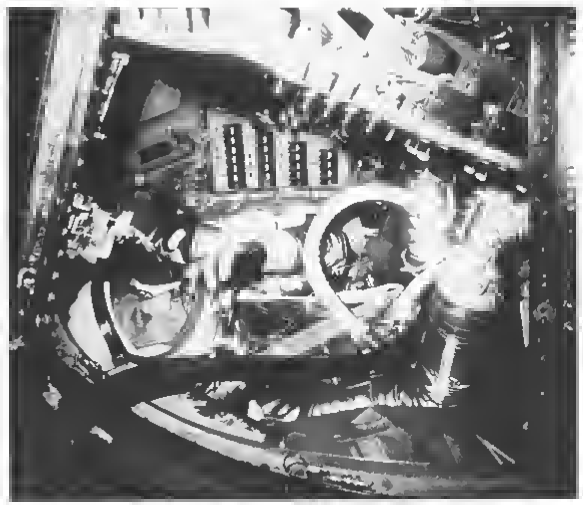
Bermuda station is the backup tracking station to Cape Canaveral for orbital insertion of a spacecraft and, as such, is considered vital to mission safety.

Inertial Orbits

Maj. Gordon Cooper made 22 revolutions of the earth and 23 inertial orbits in his MA-9 flight. The orbital figures ignore the rotation of the earth and the revolution includes it.

For every 360 deg. traveled by the pilot in his capsule, the earth below him rotated about 22 deg. in the same direction as the spacecraft's flight path.

The capsule traveled 382 deg. to catch up to the line of longitude from which it started that revolution. Inertial orbits were only 360 deg. from perigee to apogee to perigee. Period of revolution was 94.5 min.



ASTRONAUT GORDON COOPER is shown in his Faith 7 spacecraft shortly before launch.

ACTUAL FLIGHT PATH of MA 9 closely followed the programed track shown above due to accuracy of orbital injection (see box p 29) Primary retro sequence points are indicated by stars off China coast on 22nd orbit and primary landing area is indicated by large bullseye at Midway Island in the Pacific Other primary and alternate landing areas are marked by large or small bullseyes, with accompanying stars indicating retro sequence points for alternates Boxes show hours (above) and minutes (below) from launch

sphere from the capsule at 3 hr 23 mm after launch, but this simulated rendezvous experiment was only partly successful The flashing xenon light payload (AW May 13, p 34) was a piggyback satellite, 5 75 in in diameter and weighing 10 lb Objective was to have the pilot report on his ability to see the small satellite during about four orbits as it was within range of his spacecraft

The 36 year-old pilot, youngest of the original Mercury astronauts demonstrated his coolness by relaxing almost "to the point of sleep a couple of times" during the countdown and by dozing briefly between Hawaii and California on the second orbit He had reported during the first orbit that he saw the haze layer around the earth and luminescent "fireflies" (called the Glenn effect after John Glenn, who first reported sighting the particles) Cooper also said he saw the lights of Perth, Australia, during the first orbit The city had illuminated municipal and house lights in the hope that he could see them

Maj Cooper prepared for his 22-orbit mission after a one-day postponement by retiring the night before at 9 45 p m EDT He arose at 3 50 a m , ate a breakfast of filet mignon, eggs and toast, and began donning his pressure suit at 4 24 a m His weight prior to suiting was 147 lb, a pound less than he weighed the morning before

He entered the Faith 7 capsule at 5 33 a m and the hatch was bolted in place 38 mm later There was a 4 mm hold at T —11 5 mm because of an indication of difficulty in the Atlas ground-based guidance equipment and a hold of four seconds at T —19 sec This second hold, described as normal, was to allow the automatic sequencer to catch up with the countdown clock

During his fourth orbit, Cooper made voice contact with all the stations he was supposed to, and he told Astronaut Virgil Grissom at Guaymas, Mex., that he could see 'all up and down California" Then he told Mercury Control Center here that he could see 'the whole state of Florida" from Jacksonville to the southern tip and "it looked very pretty "

Cooper did not see the xenon light capsule on his third or fourth orbits but was able to see it on the fifth He first spotted it when sunlight reflected off the casing, before he saw the light itself He said it appeared to have the brightness of a second-magnitude star and appeared to be 8 to 10 mi away when he first saw it as a light When he last saw the sphere, it appeared to be 12 to 13 mi away and to have the brightness of a fourth or fifth-magnitude star "At the last, it was very dim," Cooper said

While Cooper was in the midst of his fifth orbit, Mercury officials summarized the events to that point, using nothing but superlatives to describe the performance of the pilot and his vehicle Flight Director Christopher C Kraft said it was "an extremely smooth flight Gordo [Cooper's nickname among his fellow pilots] is doing very well and so is the spacecraft "

All the bio sensors had worked well through that orbit Not a single physiological telemetry readout had been lost Mercury officials said Cooper's control of suit and cabin temperature "has been excellent" and said that the desired 30-deg differential between suit inlet and outlet temperatures had been achieved

MA-9 Notification

Cape Canaveral—U S did not formally notify Soviet Russia of Maj Gordon Cooper's Mercury Atlas-9 flight 'because the whole world could find out about the flight from government press releases," a State Dept spokesman told Aviation Week & Space Technology last week

Question arose because of Russia's announcement that it would test missiles in the Pacific Ocean between May 15 and July 15 (see p 30)

National Aeronautics and Space Administration considered the Russian tests a danger to MA 9, but the agency was assured by the State Dept that the chances of Russia testing a missile while Cooper was in orbit were remote

State Dept formally notified each country which Cooper would overfly except Red China, with which the U S maintains no diplomatic relations If Cooper was forced to land in Red China, recovery forces were prepared to go to the border and await action by the State Dept

Cooper's flight plan called for him to fly over Red China a total of 34 min during the ninth, 10th, 11th and 22nd orbits, and over Cuba on the 14th orbit for only 0 2 sec

Cooper's management of his control system fuel, his oxygen and his electrical power also drew unqualified praise Kraft said "I don't think I have ever seen a smoother flight."

During the sixth orbit however, minor problems began to develop Ground stations had no clear voice communications with Cooper from 4 49 p m EDT until 6 07 p m EDT, when he had just begun the seventh orbit Telemetry was clear during the sixth orbit, reporting a suit and cabin temperature that indicated both had stabilized, even though both the cabin fan and coolant system had been turned off

Cooper spotted ground lights at Bloemfontein, South Africa, lighted for 3 min at a time at 10 min intervals But he could not report it until later because of the communications problem He contacted the Coastal Sentry range vessel off Tokio Bay, but atmospherics that occur there at this time of year degraded the transmissions

At 6 07 p m EDT, Cooper reported clearly to Astronaut Scott Carpenter at Hawaii He said he had tried to deploy the inflatable balloon that was to be used primarily to measure atmosphere drag and secondarily to test the pilot's ability to see it, but it did not work He asked Mercury Control through the Hawaii station if he should try again He got permission but still could not deploy the balloon

He then notified Carpenter that he had drunk water and had eaten He had told ground stations earlier that he had filled one pre-flight urine bag and one in-flight urine bag At one point, when the Cape Canaveral station asked if he had drunk water, Cooper said he had and he volunteered that he had also given his first urine sample

Cooper established a new flight duration record for the U S when he passed the 9 hr 27 mm total elapsed time mark at 6 31 p m EDT May 15 during his seventh orbit Previous U S record was formerly held by Astronaut Walter Schirra, who made a six-orbit flight last autumn (AW Oct 8, p 26)

Atlas Performance

Cape Canaveral—USAF-General Dynamics/Astronautics Atlas 130-D, the booster for the MA 9 mission, was so precise in its performance that Mercury Operations Director Walter C Williams called the launch 'the best one we've had' to date in the U S manned space flight program

The Atlas gave the capsule a velocity of 25,716 fps —only 1 fps higher than planned The General Electric Burroughs radio-command guidance system placed the Faith 7 spacecraft and booster just above the middle of the orbital insertion window

The window extends 2 mi above and below an imaginary point at 99 1 stat mi altitude Actual insertion altitude, or perigee, was 100.2 stat mi Difference between the planned and actual insertion angle was only 0 0002 deg

MA 9's period was 88 6 mm and its orbital plane was inclined 32 5 deg to the equator Planned inclination was 32 46 deg

The MA-9 pilot made a second attempt to deploy the drag balloon experiment during this orbit, at about 6 10 p m EDT, but again the 30-in diballoon failed to deploy Later, Mercury officials said they believed that the most probable cause of failure was the activating squib, which should have ejected the balloon from its cylindrical canister on the spacecraft

Cooper ate and drank during this period and also exercised on the bungee cord attached to his instrument panel After exercising he took his blood pressure and reported the reading when he passed over Hawaii at about 6 07 p m EDT

Mercury Control Center reviewed all on board MA 9 systems during the sixth and the early part of the seventh orbits As the pilot approached the Zanzibar tracking station the center officials decided that the pilot could continue the flight for an additional 10 orbits Zanzibar was advised of the decision and asked to relay it to the pilot at 7 10 p m EDT

Cooper had re-oriented his capsule to a retro-fire attitude, however, in the event that the decision was made to terminate the flight at that point

At the beginning of the eighth orbit at about 8 02 p m EDT, Cooper turned on two Geiger counters mounted on the base of his capsule and the associated data tape recorder for a continuous 10 mm period These counters were to gather data on fission electrons with energy levels below 7 mev deposited in the atmosphere by the July 9, 1962, Starfish high-altitude nuclear explosion

in the Pacific A significant pocket of radiation has been identified over the South Atlantic, east of South America and just south of the tip of Africa.

The pilot also made status reports to the ship, Coastal Sentry, off Japan and to Hawaii during this orbit.

Entering the ninth orbit, in which Cooper had the choice of conducting several activities or resting, he elected to begin his sleep period and so notified the tracking ship, the Rose Knot, positioned about 3,000 mi off Chile. He reduced attitude control system power, as well as other equipment, and Mercury Control directed all stations not to attempt communications with the sleeping pilot unless an emergency developed. Physiological telemetry on Cooper's condition was transmitted throughout the sleep period and was carefully monitored by medical observers at tracking stations.

The pilot slept for about 7 5 hr according to Dr Charles Berry, Manned Spacecraft Center flight surgeon. Dr Berry reported on the morning of May 16 that Cooper's pulse rate dropped to 55 beats/min and his breath rate to about 12 inhalations/min during the sleep period. Cooper apparently experienced difficulty with his suit coolant system several times during his sleep. He later reported to ground stations that he felt warm on several occasions during that period.

Cooper drew an opaque curtain across his window and fell asleep while his capsule was somewhere between the Rose Knot and the Kano, Nigeria, tracking station as he began his 10th orbit about 14 hr after launch. At this time, he had been awake almost 19 hr.

He apparently awoke for a brief period shortly after 1 a.m. EDT May 16 during the 11th orbit to increase his suit coolant flow because the inlet temperature had risen to about 80F. At about the same time, his pulse increased from 58-60 beats/min to about 100. Some Mercury physicians speculated that the pulse rise was caused by a dream, but another possibility was that he was awakened by the steady rise in suit temperature.

Shortly before Cooper went to sleep, his pulse was 60 beats/min., respiration was 12 breaths/min., suit inlet temperature was 62F and suit outlet was 91F.

At 12 02 a.m. EDT, while he was asleep and his capsule was in free drifting flight in the 11th orbit, he had 85% of his automatic fuel and 90% of his manual fuel remaining in the attitude control system.

Cooper stayed asleep but ground stations continued to receive physiological telemetry readings automatically and Mercury Control noted "the remarkable clarity" of these transmissions.

Midway through the 13th orbit, Cooper's heart beat was 55 to 58 beats/min. and his respiration rate aout 16 breaths/min.

Cooper's attempts to transmit television pictures during the orbits before he went to sleep were only partially successful. Pictures of the capsule's interior were poor due to the lack of available light, as had been expected. But several ground stations reported good pictures of land masses and shorelines when the astronaut pointed the camera out the capsule window.

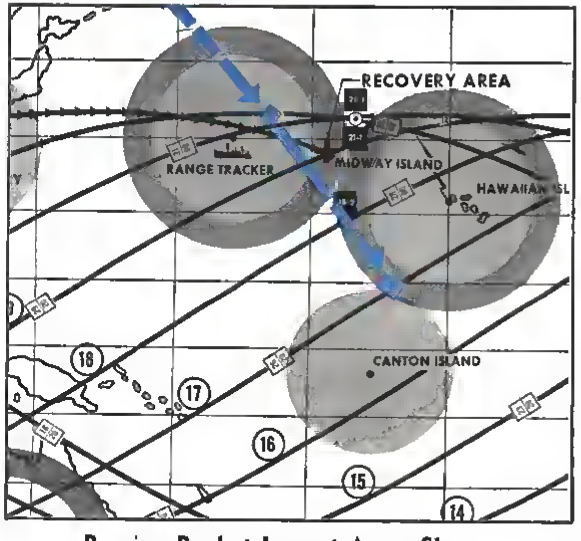
Tracking station at Muchea, Australia, was the first to hear the Mercury pilot's voice after his long sleep of approximately 7 5 hr. Cooper awoke by himself during the 14th orbit. Muchea was to have awakened him with a tone signal if necessary.

The station began receiving telemetry at 6 23 a.m. EDT May 16 and 3 min. later Cooper spoke. He said his sleep was "pretty good." He reported that he had some discomfort with the suit during the sleep period but said he had corrected it.

Cooper told the Muchea station that his suit temperature was 61F and his cabin temperature 90F. His automatic control system had 78% of the fuel supply remaining and the manual system had 96% remaining. He had been in flight for almost 21 5 hr. at this time.

Nearing the end of the 15th orbit, Cooper was described as in excellent condition by medical observers at the Cape. His suit temperature had leveled off at about 65F and his cabin, its coolant system shut down by the pilot after the fifth orbit, had stabilized between 90 93F.

Heat balance of the capsule's interior was of prime interest to Mercury program officials. If the systems installed in the pressure vessel there leveled off at a temperature reading which did not impose too severe a heat load on the pilot and his suit coolant system, it might mean that future manned spacecraft could carry fewer capsule coolant supplies.



Russian Rocket Impact Areas Shown

Impact areas for Russian rockets which the Soviets announced will be launched between May 15 and July 15 impinged on the orbital tracks of Astronaut L. Gordon Cooper's MA 9 flight last week. If launched from the Tyuratam area in Russia as in previous tests, the rockets would reach an apogee of 700 to 800 naut mi over eastern Siberia, and just before re-entry into the atmosphere would be at the Faith 7 orbital altitude. The Soviet announcement said that special ships carrying measuring apparatus would operate in the impact areas. The first area is bounded by the north latitudes 11 deg 41 min., 9 deg 3 min., 6 deg 3 min., and 10 deg 41 min. and west longitudes 167 deg 49 min., 166 deg 34 min., 168 deg 45 min. and 170 deg. The second area is bounded by north latitude 35 deg. 23 min., 33 deg 10 min., 32 deg 8 min., and 34 deg 21 min. and east longitude 173 deg 52 min., 175 deg 24 min., 173 deg 56 min., and 172 deg 23 min.

First Close-up Photo Shows F-1 Engine

First close up photo of the Rocketdyne F 1 engine emphasizes size of the 1 5 million lb thrust engine designed to power the Saturn 5 first stage. Height of the engine is about 18 ft. and thrust chamber diameter at the exit is about 12 ft. The engine is on a test stand at Edwards AFB, Calif., prior to one of the latest in the current test series of more than 40 full thrust, varying duration firings using a modified injector. This series has produced no indication of combustion instability that has been encountered in the development program.

By the middle of the flight, it was clear to Mercury Control that Cooper was managing the use of his on-board consumables as well as, if not better than, Schirra did on the MA-8 flight. "You're being real scroungy," Capsule Communicator Alan Shepard told Cooper at one point.

By the 15th orbit of the capsule Cooper still had 69% of the fuel in his automatic-mode tankage and 89% in the manual-mode tankage of the attitude control system.

At this time also, he still had 75% of the oxygen in his primary breathing tank and had not started to use his secondary supply. There were three 4-lb spheres, each pressurized to 7,500 psi, containing super-critical oxygen. Two spheres were connected to form the primary reservoir and the third unit comprised the secondary system. Electrical power used also was less than expected throughout the flight.

Between the end of the 14th and 15th orbits, approximately at 7 a.m. EDT May 16, Cooper ate breakfast and drank water. So terse were his comments to ground stations—in accordance with the pre-planned objective of keeping communications to an absolute minimum—that medical observers did not know at that time just what foods Cooper had eaten or in what quantities.

Early in the 16th orbit around 9 9 15 a.m. EDT, Cooper brought power up on the automatic stabilization and control system (ASCS). As a result, cabin temperature climbed to about 100F before leveling again. His suit temperature, however, remained at about 63F.

Automatic mode of the attitude control system was brought back in so that the pilot could execute some of the photographic experiments which his flight plan specified. These included use of a 70-mm camera, with which the pilot took photographs of the earth horizon, for Massachusetts Institute of Technology and of infrared reflectance, for the Weather Bureau. The camera was equipped with two 50 frame clip on film magazines.

For MIT Cooper fitted red and blue filters on the camera's 80 mm lens and took black-and-white pictures of the earth horizon. Purpose of this photography is to discover a constant line in the hazy horizon surrounding the earth. Photos are expected to provide data for sensors in the Apollo guidance system designed by MIT so that a spacecraft returning from the moon will be able to align itself accurately on the narrow earth re-entry trajectory. Photos also are expected to allow a more accurate analysis of sunlight scattered by the atmosphere.

Weather Bureau film was infrared, and it was contained in a separate clip-on magazine with separate filters. Infrared reflectance photography for the Weather Bureau was to record the earth and its atmosphere, including cloud cover for application to future meteorological satellites. The Nimbus weather satellite has had developmental troubles in distinguishing a true horizon from high altitude clouds in simulated tests.

During the 16th orbit, Cooper also rolled his spacecraft 34 deg. to the right so that he could, with a hand held 35 mm. camera, record night airglow and Zodiacal light.

Cooper concentrated mostly on photographic experiments during the 16th and 17th orbits. He used both the automatic and fly-by wire modes of the attitude control system to orient his capsule for the varying requirements of the photography. For the MIT pictures, for example, Cooper was required to photograph all four quadrants of the horizon, and he rolled and pitched his capsule around 360 deg. to accomplish this.

First of ten MiG-21 supersonic fighter aircraft purchased by Finland from the Soviet Union under a 1962 trade agreement (AW Nov 19, p 37) is shown on the ground in Finland. Note underwing missile pylons and low pressure, thin profile tires (below). Landing gear wells can be seen recessed into fuselage. Two 37 mm cannon positions are visible, one faired over.

First MiG-21s Are Delivered to Finnish Air Force

Ten MiG-21 supersonic fighter bomber aircraft, purchased from the Soviet Union by Finland, are shown upon arrival at Rissala Airport in eastern Finland. Aircraft were ferried by Soviet pilots, one of whom, right, was dressed in civilian clothes—the others were in military uniform.

Insignia is the blue and white roundel of the Finnish air force. Stencil markings are in English. Underwing pylons for missiles or other armament are visible as are wing fences and various bulges. Ram air intakes for afterburner cooling are visible above towards the rear of the fuselage and the air intake spike can be seen in the nose engine air inlet. Bulge on vertical fin is for the rudder power boost unit.

Small tracking radar is located in the inlet spike and the aircraft also has a conventional gunsight reflector glass.

Clearance of the finned fuel tank hung from the center pylon is evident above. Photo, however, shows effects of foreshortening by telephoto lens (AW July 24, 1961, p 28). Canopy swings up and forward.

Second West Ford Launch Is Successful

By Roderick D. Hibben

Air Force launched 50 lb. of copper needles into orbit around the earth May 10 with an Atlas Agena vehicle from Pt. Arguello, Calif., and successfully ejected them in a second attempt to carry out Project West Ford.

Criticism of the program, a feasibility study of a potential high reliability, long-range radio communication link using a belt of copper needles, continues from parts of the scientific community despite earlier Kennedy Administration efforts to mollify such opposition by appointment of a study panel of the President's Science Advisory Committee composed of well known astronomers (AW Aug. 21, 1961, p. 31).

Radar confirmation of the ejection of the needles and the initial rate of dispersion, made by Massachusetts Institute of Technology's Lincoln Laboratories, followed by one week public notification of the impending launch USAF had advised the National Academy of Science of the planned launch and the Academy's Space Science Board in turn conveyed this information to the international scientific community and to volunteer observers and observatories throughout the world in a May 3 memorandum to the West Ford Committee of the International Astronomical Union.

Initial criticism of Project West Ford centered on whether or not a copper belt circling the earth would interfere with detection of weak signals from distant radio galaxies.

Subsequently, the controversy shifted to differing estimates of the needles lifetimes once they were placed in orbit. They ranged from official government estimates of relatively short lifetimes to far longer lifetimes predicted by independent calculations (AW Apr. 22, p. 27).

Current protests voiced in the U.S. and abroad have questioned claims made by Lincoln Laboratories that this type of communications system would be invulnerable to jamming or destruction.

While admitting advance study indicates negligible interference to optical and radio astronomical measurements by the 50 lb. of needles, one university astronomer said the success of this type of communications system depends upon ultimate creation of much denser copper belts, which could seriously impair observations of all kinds.

Scientists exclusive of radio astronomers, alluded to expectations of heightened activity in atmospheric contamination once precedents such as Project West Ford were set.

The first Project West Ford launch attempted to orbit 75 lb. of copper needles in October, 1961. It ended with a mechanical malfunction of the needle dispensing mechanism which prevented the filaments from dispersing.

The copper needles from the recent successful launch are in an approximately polar orbit at an altitude of about 2,000 mi. The belt lifetime is expected to be five years at the most. Radiation from the sun striking the copper filaments will then force them into the denser lower atmosphere where they will burn up.

Belt formation of the needles is expected to take a month while uniform distribution of the needles will take about 60 days from launch. Belt is expected to be 5 mi. wide, 25 mi. thick and 40,000 mi. in circumference. Each cubic mile of the belt will contain about 50 needles with average spacings between needles of more than ½ mi.

Reduction in weight but not number of the copper dipoles was accomplished by decreasing their diameter from 0.001 to 0.0007 in. This resulted in a total of 400 million needles while the first attempt used 350 million.

Launch package weighed 90 lb., of which 15 lb. was telemetry equipment and 50 lb. was the copper filaments. The rest of the assembly weighed 25 lb.

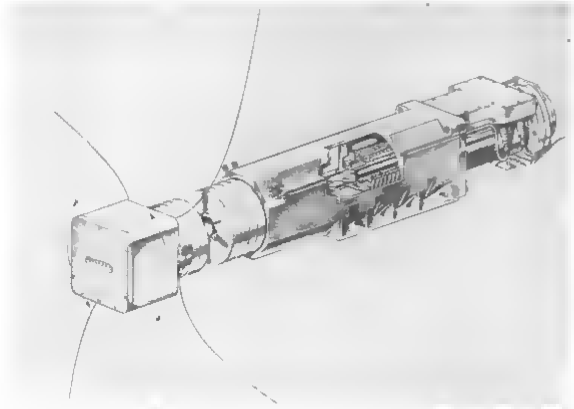
Each dipole, ½ in. long, acts as an individual passive communication satellite. This technique, called the orbital scatter method of communication, promises high reliability since the radio equipment is located on earth where maintenance is easily accomplished.

The copper dipole belt would furnish a large number of communication circuits between different geographic ground stations, the number being determined by the size of the belt and the radio equipment available. Two such belts, an equatorial and a polar belt could, in principle, permit communication hook-ups between any two points on earth in no more than two transmission links.

The copper needles in the belt system are tuned like miniature dipole antennas to give strong reflections at frequencies of about 8,000 mc./sec., while producing negligible reflections at other frequencies. The advantages of using higher frequencies are the availability of bandwidths and the stability of transmission of the radio signal during solar phenomena, such as sun spots.

Scientific measurements to be performed as part of West Ford will be radar measurements of the rate of growth of the dispersing belt as it forms, of its dimensions and of its orbital path. Continued radar measurements after formation of the belt will determine the effect on belt size and shape of radiation from the sun, micrometeorite or electrically charged particle bombardment, and the possible interaction of the belt with the earth's magnetic field.

Advanced techniques of modulation developed for Project West Ford achieved a digital data transmission rate of 50,000 bit/sec. on a lunar relay circuit between the Millstone Hill, Westford, Mass. ground station and Camp Parks at Pleasanton, Calif., 3,000 mi. apart. Both stations are equipped to attempt simultaneous two-way transmissions as well as to make radar measurements and transmit and receive communications signals for radio propagation measurements.



NEW DEVICE used to dispense copper needles in Project West Ford is shown in drawing

Jet Commander Price to Increase

Price of the Model 1121 Jet Commander will be increased approximately $75,000 for the second production block of aircraft, according to Aero Commander, Inc., Bethany, Okla.

Price rise is due to an increase in prices of vendor items and production costs. The boost will bring the Jet Commander price to $550,000. It will take effect from the 51st airplane. The company is not specifying how many airplanes in the next block it will offer at the new price.

Aero Commander is standing on its original price of $475,000 for the first 50 airplanes already committed to production line position by corporate customers, distributors and other purchasers. One sale has been made to an Italian customer.

Aero Commander says that the major portion of the price increase was required by increased cost of vendor supplied items, some of which are actually going into the initial production block. Aero Commander is absorbing this cost because of previously signed customer agreements.

Some detail design changes, such as relocation of electronics equipment from a non-pressurized into a pressurized area, are adding to the cost, although this is a change that will be incorporated from the first production airplanes onward. Aero Commander also will provide wing and tail de-icing equipment as standard items, instead of optional, because initial orders have all specified this equipment.

Congress Authorizes $15.3 Billion For Aircraft, Missiles and Ships

By George C. Wilson

Washington—Defense Dept. last week received congressional authority—not the actual money—to spend $15.3 billion in Fiscal 1964 for the procurement and development of aircraft, ships and missiles as the House and Senate agreed on a compromise bill.

House won restoration of many of the earlier Senate cuts before sending the bill to the White House for President Kennedy's signature. Restorations included $213.7 million for aircraft procurement and the $94.8 million cut from the Boeing Minuteman, Martin Pershing and Goodyear Subroc missile programs. Senate had suggested the Fiscal 1964 buy be reduced by 235 aircraft. In a conference with the Senate, the House lowered this total to 145.

The measure reflects the economy mood prevailing in Congress. Although the total difference between what President Kennedy requested and Congress authorized is $44.4 million, the actual cut in his request is $408.1 million because of the $363.7 million Congress added for the USAF North American RS-70 (AW May 13, p. 25). The Administration cannot spend the RS-70 money for any other purpose.

These are the totals for procurement and research for aircraft, missiles and ships for Fiscal 1964:

President requested $15,358,691,000, House authorized $15,856,391,000, Senate authorized $14,951,491,000; final compromise $15,314,291,000.

• **Aircraft procurement.** Congress reduced the Fiscal 1964 aircraft procurement request of the Air Force from $3,359,000,000 to $3,448,600,000, Navy and Marine Corps from $1,958,700,000 to $1,938,700,000, and Army from $522,100,000 to $503,600,000.

Even if the appropriation committees do the unexpected and appropriate the full amounts authorized, it is still not certain how many aircraft would not be ordered to achieve the economies ordered by Congress. This is because unit prices of aircraft change according to the size of the production order. Also the services could legally elect to stay within the ceilings set for the general categories of aircraft, missiles and ships through economies different from those suggested by Congress. So the suggestions about what not to buy in Fiscal 1964 are significant.

Air Force. Congress suggested the Air Force absorb the $110.4 million cut in its aircraft procurement account by reducing its purchases by about 30. McDonnell F-4Cs and RF-4Cs saving about $70 million, 10 Lockheed C-130Es saving $32.4 million, 11 Northrop T-38As, saving $8 million. This is 51 fewer aircraft than the 964 Air Force requested. Senate voted originally to cut the budget for such related aircraft equipment as modification items and spares by $35.3 million, but this amount was restored in the final bill (AW Apr. 22, p. 26). In its bill, the Senate also said the Air Force should buy 35 fewer F-4Cs and 29 fewer RF-4Cs for an estimated saving of $154.3 million. The original Senate cut amounted to 85 aircraft.

Navy. Congress suggested the Navy and Marine Corps absorb the $20 million cut by reducing its aircraft purchases by 12 McDonnell F-4Bs, a saving of $13 million, and four Grumman TC-4B Gulfstream navigation trainers, a saving of $7 million. This is 16 fewer aircraft than the 681 requested. Senate originally cut the Navy aircraft budget by $127.8 million, suggesting 37 aircraft not be purchased. Senate also had cut $30.3 million from the aircraft support equipment budget, but this was restored in the final bill.

Army. Congress suggested Army absorb the $18.5-million budget cut by reducing its planned purchases of aircraft by 35 Bell OH-13S Sioux and Hiller OH-23 Raven helicopters, eight de Havilland CV-2 Caribou transports, 10 Grumman OV-1C Mohawks, 10 undesignated instrument trainers and 15 undesignated primary trainers. This is 78 fewer aircraft than the 1,598 requested. Senate originally slashed the Army's aircraft budget by $50.9 million, suggesting that 25 Bell UH-1B and D Iroquois helicopters and 10 Vertol CH-47A Chinook helicopters not be purchased. This would have meant $8.3 million less to spend for the Iroquois and $23.8 million less for the Chinook. Final bill restored these cuts.

• **Missile procurement.** For missile procurement in Fiscal 1964, Congress restored cuts in the Air Force budget and voted the full $2,177,000,000 requested; authorized the $1,107,300,000 requested by the Navy and $14,700,000 by the Marine Corps; reduced the Army request from $580,700,000 to $565,700,000.

Air Force. Senate originally cut $67.6 million from the Boeing Minuteman budget, but this was restored. Also restored was the Senate cut of $8.2 million in the missile supporting equipment procurement budget.

Navy. Congress restored the $12.2 million Senate cut in the Goodyear Subroc anti-submarine missile program.

Army. Congress reduced the Senate's $30 million cut in the Martin Pershing procurement account to $15 million.

Navy requested $2,310,000,000 for ships in FY 64. House approved the Senate cut of $150.4 million.

House also approved the Senate-imposed 3% across-the-board cut in research and development for all the services, lowering amounts requested in that category to these maximums:

• **Aircraft.** Air Force from $322,986,000 to $313,286,000 with an additional $363.7 million available only for the RS-70; Navy and Marine Corps from $204,183,000 to $198,083,000; Army from $82,148,000 to $79,748,000.

• **Missiles.** Air Force from $1,060,132,000 to $1,028,332,000; Navy and Marine Corps from $590,133,000 to $572,433,000; and Army from $576,601,000 to $559,301,000.

• **Ships.** Navy from $293,008,000 to $284,208,000.

Reconnaissance Module Proposals Sought

By Barry Miller

National Aeronautics and Space Administration's Manned Spacecraft Center has asked for proposals from aerospace companies for a spacecraft module, capable of launching unmanned reconnaissance probes from a lunar orbit (AW May 13, p 23) raising questions as to the future of the Surveyor lunar orbiter program.

System is intended for reconnoitering the moon's surface as part of Apollo operations. New vehicle called the Lunar Reconnaissance Module (LRM), would be substituted for the Lunar Excursion Module (LEM) on the first Apollo circumlunar flights to gather essential surface data at potential lunar landing sites before a manned landing attempt.

Proposals, to be submitted by June 7, would cover two separate six-month preliminary system and payload design studies relating to this lunar reconnaissance mission.

Continuing lunar reconnaissance activity at the Manned Spacecraft Center and the probability of a manned lunar reconnaissance mission casts additional doubt over the value and future of the unmanned Surveyor orbiter program, which has been stalled over the past three years by alternating periods of indecision, delay and false starts (AW Oct 17, 1960, p 27, July 23, p 22, Mar 4, p 25).

The orbiter program originally planned for a purely scientific lunar-mapping mission was to be altered to assist the Apollo manned program in landing site selection, but has not been implemented.

Should site selection and verification from lunar orbit be incorporated in the Apollo program—as the Manned Spacecraft Center suggests in its recent proposal requests and as the nature of its projected studies strongly implies—the need for a separate supporting Surveyor orbiter may vanish.

MSC regards manned lunar reconnaissance as a means for boosting the probability of Apollo mission success.

Reconnaissance techniques, including probes which MSC is exploring could give Apollo more information about lunar landing sites than an unmanned Surveyor could. Surveyor is severely restricted by lighter payloads, lower resolution camera systems and the absence of on-board human operators.

The reconnaissance module may have capability of launching from lunar orbit one or more unmanned reconnaissance payloads or probes. These would be designed to survive impact on the moon and secure data about the nature of lunar surface slopes, surface bearing strength and the magnitude and distribution of surface protuberances and depressions.

Weighing less than 1,000 lb each, the probes would help to verify the safety and selection of prospective LEM lunar landing spots.

The two companion proposal requests an outgrowth of a growing MSC interest in the reconnaissance module cover:

- **Reconnaissance systems** for manned lunar missions for which MSC has $200,000 available. This will look at all sensors—radar, infrared, photographic and visual techniques—for obtaining data from an 8- to 80-naut mi-altitude lunar orbit for selection and verification of manned lunar landing sites. The systems are expected to pinpoint these sites to within a probable error of less than 400 meters with respect to a selenographic coordinate system.
- **Lunar reconnaissance** probe systems, a $100,000 effort by MSC. The availability of unmanned lunar probes would extend astronauts' reconnaissance capability from the orbiting spacecraft to the moon's surface. Once an area is examined by on-board sensors, the probe could be launched from the spacecraft for closer exploration.

At the conclusion of these six-month studies, hardware development contracts, which might lead into a multi-million-dollar effort are anticipated.

Reconnaissance systems in both of the current studies are to be capable of reaching operational status in time to be integrated into the first Apollo lunar mission. All system concepts are to be fixed by the middle of next year.

Two possible spacecraft configurations are being assumed by MSC for purposes of its dual industry studies. These are reconnaissance with:

- Apollo command and service modules docked to the reconnaissance module. On this mission, the reconnaissance module would effectively replace the Lunar Excursion Module which, on subsequent missions will carry two astronauts to the lunar surface. Such a configuration is assumed for the reconnaissance probe study.
- Apollo command and service modules mated with the LEM. Both this approach and one involving the reconnaissance module docked to the command module are to be considered. In this case, the LEM functions as the reconnaissance module.

Information of major interest in the reconnaissance systems study will be:

- Magnitude and distribution of surface protuberances and depressions.
- Lunar surface slopes.
- Locations and elevation of mountains and ridges in the approach and take-off paths of potential landing areas.
- Lunar surface environment. Lunar areas of interest lie within ±10 deg selenographic latitude, ±60 deg selenographic longitude.

For site selection, resolution of interest requires that a circular cone 50 meters high, with slopes inclined 15 deg to the horizontal, is to be recognized and displaced by reconnaissance systems in a single mission.

For site verification, a circular cone 50 cm high, with sides inclined 8 deg with respect to average surrounding terrain, must be recognized and displaced. The systems will have to differentiate among objects of 0.3 meters, identify those over one meter.

Secondary goals of the systems study include recommending methods of establishing photogrammetric and selenographic control points, evaluating systems capable of providing imagery for use in producing topographic maps, and evaluating systems which can give imagery of large segments of lunar surface not suitable for landing in early manned missions. Means of determining gross features of moon's far side are also to be considered.

No major changes in the command or service modules are expected to result from the study and none will be made that would compromise lunar landing mission capability. Constraints of reconnaissance mission duration will be established by the seven-day nominal lunar orbit period of the command and service module.

LEM is restricted to a maximum use of 48 hr. Maximum reconnaissance data weight returnable to earth in the command module would be 150 lb for the command-service LEM combination, 250 lb for the reconnaissance module configuration.

The reconnaissance module cabin volume will be between 500 and 700 cu ft, allowing 3,000 lb for on-board reconnaissance gear. Volume available for reconnaissance systems in the LEM-command module combination would be 15 cu ft., two thirds of this in the command module. This space would accommodate less than 500 lb of equipment, but MSC regards 250 lb as a preferred maximum limit.

Probe launcher, delivery system and landing system will comprise the lunar probe system. Reconnaissance probe and launchers are not to exceed 11,000 lb. From the Apollo spacecraft in an 8- to 80-naut- mi orbit the system is to be able to crash land a survivable payload, or possibly the center of a cluster of survivable capsules, within a one sigma accuracy of 1,600 meters of a selected point on the lunar surface.

One important objective of the surviving payloads will be to make measurements of the lunar crust's static bearing strength which will affect the capability of a lunar lander, such as LEM, to land satisfactorily on the lunar surface.

Surface payloads will be expected to define the texture and relief of the lunar surface. They should obtain data from which it may be possible to discriminate objects of 10 cm from a distance of 30 meters. One possibility to be investigated will be a probe that can make five or preferably more than 10 measurements to determine bearing strength of the surface at random points within a 1,600 meter radius (about 0.86 naut. mi.).

One or more types of payloads may be necessary to accomplish the reconnaissance mission, the number of probes being a trade-off of maximum coverage of an area against the detail with which an area may be examined.

For design purposes total volume for probes and launchers will be 700 cu ft.

Probe study objectives include:

- Determining operational procedure and sequence for launching payloads to the surface and receiving data.
- Designing manned spacecraft systems to command the probe, receive, record and display data returned from the surface payloads.
- Defining environmental control and protection for probe system.
- Defining on-board equipment to track the probe to lunar impact and verify that location to a one-sigma accuracy of 60 meters.
- Recommending possible use of a passive or an active beacon aboard the probe.
- Determining what probe functions before and after impact can or should be commanded by the crew from the manned spacecraft.

Special attention is to be devoted to making the probe system compatible with the Apollo spacecraft. The former will have to be launched within the limits of Apollo attitude stabilization. These limits are ±½ deg in pitch, roll and yaw with pitch, yaw and roll rates at 1.2 arc min/sec. Should greater stabilization accuracy be required, it may be achieved by manual spacecraft control during probe launch.

While most or all data obtained in the reconnaissance mission will be carried back to earth aboard the Apollo spacecraft, key items may be transmitted from the orbiting spacecraft back to earth via the S band data link in the command module.

One reason for extending regions of reconnaissance interest beyond those areas of the surface suitable for landing is to obtain fundamental information about the moon from observations of its properties. The moon probably will be observed photographically during the translunar phase of the mission and possibly while the spacecraft orbits the far side.

Both the probe and lunar reconnaissance studies are part of MSC's lunar reconnaissance missions study. The center is to be responsible for integrating reconnaissance systems into the spacecraft.

Military Comsat Studies Awarded

Washington—Air Force last week awarded two-month contracts for concurrent program definition studies on medium altitude, random orbit communication satellites for military use (AW Apr 15, p 27). One contract was awarded to a team of the Philco Corp. and Space Technology Laboratories, Inc., and the other to the General Electric Co. Motorola, Inc.'s Military Electronics Div. is associated with GE in this effort. Proposals were selected from 30 firms.

Both studies are to include proposals for a technical approach, refined cost estimates and internal management for development of the satellite. If the Defense Dept. decides to proceed with the communications satellite system, one of the two contractors would be selected to develop and build the satellite. The Army has responsibility for the ground station system.

Air Force has proposed a system of 20-30 satellites in a 6,000 mi. orbit. Satellites would weigh between 80 and 120 lb. and would be placed in orbit with Atlas Agena launch vehicles. As many as five or six satellites would be injected into orbit on each launch. Estimated cost of the system is $200 million to $250 million, and Defense Dept. hopes to have an operational system by late 1965.

Air Force emphasis is on use of proven systems and components. Development of the military satellite will borrow wherever possible from the demonstrated technologies of the Telstar, Relay and Syncom programs.

Defense Dept. maintains it needs a separate system because of a requirement for security, a mobile military control and command capability and a system that cannot be knocked out by electronic countermeasures.

Air Force Space Systems Div. is program manager for satellite development. Defense Communications Agency has responsibility for ensuring compatibility of the satellite and ground systems.

IAM Accepts New Boeing Pact

Washington—International Assn. of Machinists last week voted decisively to accept a new three-year contract with Boeing Co., ending 10 months of negotiations.

About two-third of the 30,000 IAM workers at Boeing plants and facilities voted. The result was 14,205 for ratification and 4,688 opposed.

This was the second ratification vote on a "final offer" by the company before strike action. IAM members previously approved a strike by a 9,591 to 8,723 vote (AW Apr 29, p 27). At the request of President Kennedy, union leaders and company representatives promptly resumed negotiations leading to the second vote on a slightly modified contract (AW May 6, p 36).

William E. Simkin, director of Federal Mediation Service, called the IAM vote "extremely welcome news" and commented:

"This not only insures uninterrupted production of the important Minuteman missile at Boeing, but it represents the conclusion of a successful round of negotiations in the entire aerospace industry—accomplished with the aid of the mediation service, without serious work stoppage. This is a new tribute to free collective bargaining."

It is estimated that the new contract will cost Boeing over $6 million in retroactive pay to last September, when the former labor contract expired. The additional cost for the first year is estimated at between $11 and $14 million. During the second and third years there will be an additional cost of about $7 million a year.

Countermeasures A-6A

Grumman Aircraft Engineering Corp. has flown the prototype of an electronic countermeasures version of its A-6A Intruder Navy carrier based attack aircraft.

Countermeasures version, designated EA-6A and designed to accompany A-6A squadrons to confuse radar-controlled enemy anti-aircraft weapons and detecting devices, will go into production in 1964.

VJ-101C Flight Tested

Manching Germany—Subsonic prototype of the Bölkow Henkel Messerschmitt VJ 101C VTOL interceptor, designated the X 1 was successfully demonstrated in hovering flight here last week, by American test pilot George Bright. First supersonic version, the X-2, is due to rollout this week.

Test flight maneuvers included vertical ascent to approximately 100 ft forward and lateral hovering flight and stationary 360 deg yaws. The aircraft appeared to be stable and seemed to handle well. Vertical landing in a slight nose-up attitude—with the main wheels of the tricycle gear touching down first—was very smooth. Flight duration was approximately 15 min.

Aircraft will be flown conventionally from a rolling horizontal takeoff, before making first full transition from vertical to horizontal flight scheduled for mid-June.

Prime difference between the X 1 and X 2 versions lies in the four podded wingtip Rolls-Royce RB 145 turbojets. In the X-2 the engines are fitted with afterburners, which boost the thrust of each engine from 2,750 to 3,650 lb. The two RB 145s mounted in the fuselage directly behind the cockpit are used only for vertical thrust (AW May 13, p. 35) and hence will be essentially the same in both prototype versions. The nozzles will not protrude beneath the fuselage in the X-2, however.

Total thrust of the six X 1 engines is 16,500 lb. A pair of lift engines is mounted in each swiveling pod on the wing tips. Transition from vertical to horizontal flight is achieved by varying thrust direction of the tip engines by tilting the pods from the vertical to the horizontal position. The two engines mounted in a fixed vertical installation in the fuselage are shut down in horizontal flight and main propulsion is provided by the four tip engines.

Tethered tests started at Manching last December and initial tests on autopilot stabilization were conducted last February under partial tether conditions. First free hover was performed on Apr. 9, to heights of about 100 ft. with Bright at the controls.

An intake system capable of supplying air to the engines during vertical liftoff, pod swiveling in the transition phase and at high Mach numbers in normal flight was achieved by designing the intake cowl to move forward thus exposing additional intake area for use under static, transition and low flight speeds. To minimize the pod frontal area, the engine and accessories installation are kept compact. All mounting loads, fluid and control systems pass through a single attachment point on the swiveling axis of each engine pod.

The RB 145 engine is an axial turbojet derived from the RB 108, the engine used on the Short SC 1 VTOL research plane.

Canada to Accept Nuclear Arms

Washington—Canadian Parliament is expected to approve the arming of Boeing Bomarc B surface-to-air supersonic ramjet-powered guided missiles in Canada with nuclear warheads in line with an agreement between President Kennedy and Canadian Prime Minister Lester B. Pearson.

The agreement was the outgrowth of earlier U. S. pressure on the Conservative government of former Prime Minister John Diefenbaker (AW Feb. 11, p. 30). The warheads are expected to be installed by the end of the year.

A joint communique issued after President Kennedy and the Prime Minister conferred May 10 and 11 said:

"The Prime Minister confirmed his government's intention to initiate discussions with the United States government leading without delay towards the fulfillment of Canada's existing defense commitments in North America and Europe, consistent with Canadian parliamentary procedures."

Early in February, the Social Credit and New Democrat parties joined with Pearson's Liberal Party to topple the Diefenbaker government over the issue of nuclear warheads in Canada.

Diefenbaker's policy was attacked in January in a State Dept. release which traced negotiations with Canada on the Bomarc B warheads. The two Bomarc B squadrons deployed to Canada were useless without the nuclear warheads and Diefenbaker would not agree to arming them with nuclear warheads.

Comsat Official Named

Washington—Allen E. Throop, now a partner with the New York law firm of Sherman & Sterling, last week was appointed vice president-general counsel of Communications Satellite Corp.

In his new position Throop, 63, will be the key figure in arranging the new corporation's stock issue. He is a graduate of Harvard Law School and previously served as general counsel of Securities and Exchange Commission. He was chairman of the committee on federal regulation of securities of the American Bar Assn. during 1960-62.

News Digest

Army last week awarded three parallel $500,000 four-month study contracts for its Army Air Defense Systems for 1970 (AADS-70) to teams headed by Hughes Aircraft Co., Radio Corp. of America and Raytheon Co. (AW Apr. 22, p. 23).

De Havilland Aircraft of Canada has received a $12.5-million order for 16 Caribou 1 utility transports from the Indian government. Canadian government is lending India the money for the purchase. Deliveries will begin in July and the full order is scheduled for completion within a year.

Celestial Inertial Test Complex, designed to measure the performance of celestial guidance systems, is being built at Central Inertial Guidance Test Facility at the Air Force Missile Development Center, Holloman AFB, N. M. It is to be completed this year.

Dr. Robert W. Buchheim, head of Rand Corp.'s Aero-Astronautics Dept., has been named to succeed Dr. Laumor F. Carter as chief scientist of the Air Force, effective in July.

U. S. and Great Britain have signed an agreement permitting the U. S. to build the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Bahama Islands between Andros Island and Exuma Sound, where the water is 4,200 ft. to 6,000 ft. deep. The center, which has been planned for three years, will be used to test underwater detection devices, torpedoes, missiles and communications.

Dr. Robert L. Sproull, director of Cornell University's materials science center, has been named director of the Advanced Research Projects Agency (ARPA), under the director of defense research and engineering. He will relieve Dr. John P. Ruina, ARPA's project director, about Sept. 1.

Inflatable micrometeoroid paraglider (IMP), developed by Space-General Corp., El Monte, Calif., failed to inflate in its first re-entry test last week at White Sands Missile Range, N. M. IMP is being developed for NASA's Langley Research Center (AW Oct. 8, p. 35).

Approval of the expanded airline mutual aid pact was recommended last week by Civil Aeronautics Board Examiner S. Thomas Simon. If CAB approves the pact, Eastern Air Lines legally will be able to apply $16 million it collected from pact members during a strike last year to offset its reported $13.3 million net loss for 1962.

New U.S. Policy Backfires in Rate Fight

Persuasion fails in IATA fares dispute; United States capitulates in face of British threats to seize aircraft.

By L. L. Doty

Washington—U. S. last week applied its new international civil aviation air policy in the chaotic fare crisis by using "persuasion" rather than "coercion" with Great Britain and got only coercion in return.

Observers here are viewing U. S. capitulation to England on a fare increase, predicted by AVIATION WEEK & SPACE TECHNOLOGY (May 6, p. 38), as leaving the new policy limp, ineffectual as an instrument in future dealings with foreign nations on international civil aviation matters. The success of the British, backed by a strong united European front, in forcing its will on the U. S. stirred storms of congressional protest and prompted the White House to sponsor legislation giving the Civil Aeronautics Board rate-making powers over international fares.

As matters stood late last week, the slight fare increase on North Atlantic routes, adopted last fall by the International Air Transport Assn. traffic conference at Chandler, Ariz., will now apply until Sept. 12. The CAB surrendered to British demands after Secretary of State Dean Rusk advised the Board to modify its opposition to the fare increase, and after the British threatened to "detain"—a polite word for impound—any U. S. jets accepting passengers at the lower pre-Chandler fare.

Within 24 hr. after the capitulation, an irate Sen. Warren Magnuson (D-Wash.) called hearings by his Commerce Committee in an effort to get to the root of the problem. Other than subjecting CAB Chairman Alan S. Boyd and State Dept. officials to sharp and often critical questioning, little appeared to have been achieved by the hearings, although they may have focused new attention on the bill proposing the rate-making legislation.

The new policy has suffered a severe setback, not only because of a loss in U. S. prestige, but because its very spirit was undermined. Its stated principle that international aviation must be treated as a business enterprise in the solution of air transport problems was nullified by the fact that the relatively simple issue of a $27 fare increase created a crisis at top diplomatic levels and launched a debate in the British House of Commons.

In addition, the policy's call for lower fares has been bluntly disregarded by all nations except Canada and possibly Chile, Japan and Mexico. Boyd pointed out that the Canadian government, which holds rate-making authority, has successfully enforced the pre-Chandler fares on all flag carriers serving Canada through the North Atlantic routes. He added, that, if armed with similar authority, the U. S. can be assured of lower fares in the near future.

Chief failure of the policy brought about by the fare battle has been the inability of the U. S. to negotiate by persuasion rather than by coercion, a key element to the policy's intent. It now appears evident that the U. S. will gain its goals in international air transportation only through hard-headed negotiating at high government levels.

This is borne out by a statement made last week by Julian Amery, British Minister of Aviation, before the House of Commons. In reference to a conference held this month on the problem (AW May 6, p. 42), he said:

'Mr. Boyd made it plain that he had not come to London to compromise. I have to tell [the House] that at one time the discussions became so frigid that we had to propose an adjournment. In the end we had to record an agreement to disagree.'

These are the major events that led the United States to drop its demands that the lower pre-Chandler fare be retained:

- **When the pre-Chandler fares expired** May 12, no European nation showed any signs of accepting the U. S. position. Boyd later admitted he had misjudged the degree of unity of the European carriers, and had erred in calculating that several would break from the British stand as the May 12 deadline drew close. Germany did waver momentarily but returned to the group quickly, although the German government deplored recourse to such pressures as the cancellation of landing rights. Most European carriers resent the heavy governmental interference brought about by the rate struggle.
- **On May 13, Julian Amery** made a blistering attack on the U. S. position in the House of Commons. British Ambassador to the U. S., Sir David Ormsby-Gore, was instructed to make the "strongest representations" to the U. S. government on the issue. The protest was delivered to Rusk by British Embassy official Dennis Greenhill.
- **Sen. Magnuson,** in a strongly-worded Senate speech said the U. S. must stand fast and not be "dictated to" by foreign flag carriers.
- **In a letter to Rusk,** Boyd noted that the "strong representations" have moved the controversy from an economic to an overall international relations area. He added that "we should be interested in receiving such reactions and advice in this matter as you may see fit."
- **On May 14, Rusk replied that,** in the absence of ratemaking authority and to protect the competitive position of U. S. carriers, the CAB should modify its stand "insofar as is necessary not to subject the carriers to penalties for violation of laws and regulations of foreign countries."
- **Boyd advised Pan American** and TWA that earlier instructions directing the two carriers to maintain current fares were modified in compliance with the State recommendation. On May 1, Board Vice Chairman Robert T. Murphy had told the two carriers that European governments should be told that

VC.10 Fixes

London—Aerodynamic fixes to the wing lift devices and engine mountings of the Vickers VC.10 have corrected the airplane's adverse drag conditions. Fixes made on the No. 5 airplane for test purposes will be incorporated on the preceding four VC.10s and on following production models.

The drag problem (AW Apr. 1, p. 40), was termed corrected last week by Minister of Aviation Julian Amery. Vickers confirmed the minister's statement but would not reveal any details, pending further in-flight investigations and collation of the present data.

Amery also said a final decision has not been made on stretching the Super VC.10 to fly nonstop from London to Los Angeles, pending completion of the drag tests. Major drag fixes involve tilting the nacelles 3 deg. upwards and modifying the slats.

the CAB expected U S airlines to adhere to pre-Chandler fares. This Boyd letter paved the way for the two carriers to file tariffs with the CAB.

• **On May 15, President Kennedy** sent a proposed bill to the Congress which would give the Board authority, subject to approval by the President, to control rates in international air transport to and from the U.S. On the same day the Senate Commerce Committee conducted its hearing.

• **The traffic conference** opened a special meeting in Bermuda May 16 and representatives of a number of European carriers met in Brussels on the same day to discuss the fare problem. In letters to TWA and Pan American, with respect to the Bermuda conference, Boyd stressed his desire for a return to the pre-Chandler fares. Failing this he asked that a compromise be considered maintenance of the round trip discount at 5%, with an offsetting decrease in one-way fares. "Finally, it is our desire that any new transatlantic fare agreement which may be reached at the Bermuda meeting be limited in duration to Mar. 31, 1964," he said.

During the Senate hearings Boyd conceded that it might be possible to interpret the Federal Aviation Act of 1958 to mean that the CAB has the power to fix rates when the public interest would so require. He said however, the Board had found in its studies that the rate increase in question was so small it could not be classified as "detrimental" to the public interest.

He also said that the U.S. had not asked for consultation and then arbitration with the governments involved as permitted under the terms of bilateral agreements, because such actions are usually drawn-out and the new fare would be in effect until a settlement had been reached.

Boyd conceded that the U.S. does have certain powers to suspend or approve international rates, but he said that authority has never been implemented to specify the CAB is holding such power. He said only legislation would detail which department or agency should exercise that authority.

On this point, Boyd drew a sharp difference of opinion from Sen. A. S. Monroney (D.-Okla.), who held firmly that the CAB had all the power it needed to impose the new fares on foreign flag carriers. Boyd said, under CAB counsel's findings, the Board has no such authority without legislation.

At one point, he was asked what would happen if the U.S. cut the European carriers from serving the U.S., and Sen. Vance Hartke (D.-Ind.) promptly interjected that "they would ask for consultation fast enough."

Boyd was asked by Magnuson why foreign flag carriers, with government support and heavy subsidies, were incapable of showing profits comparable to U.S. airlines. Boyd replied that this was a question he had never been able to answer. It was his feeling, he said, that if they cannot make money with the same planes and same services offered by the U.S. airlines, they should not be operating across the Atlantic.

Earlier, in London, Amery told Parliament that "we were astonished to see the Civil Aeronautics Board disapprove the decision of 90 airlines without any previous warning and only a few days before those decisions were due to be applied ... " He added:

"It was our general view that things had gone so far that these fares must now be introduced for an interim period at any rate—it might be for a year or even less—and that meanwhile there should be a meeting of representatives of governments and later of IATA to try to resolve the position and, if they so thought it right to revise the Chandler decisions."

Boyd outlined events leading up to the CAB decision to oppose the fares.

• **Prior to the Chandler traffic conference,** the Board consulted with U.S. flag carriers to discuss the general fare situation. It was not contemplated that an increase would develop.

• **Conference ended** in late October (AW Nov. 6, p. 44) and the Board was advised by IATA of the tariff resolutions in late November. Both TWA and Pan American had opposed the increase, favored a reduction of first-class fares and agreed to the raise as a conference compromise to differences that threatened to end in a deadlock.

• **Board met in December** on the issue and wrote each carrier for their views on the fare increase. A letter was received from Pan American on Jan. 12 and another from Northwest on Jan. 25 but none was received from TWA. No airline attempted to justify the fare increase, but said agreement was made to retain unanimity within IATA.

• **On February 12, the CAB** tentatively found that the proposed fare increase was not in the public interest and asked IATA to file papers to justify its position. This was done, but the CAB was not satisfied.

• **On Mar. 18, the CAB** issued its final decision disapproving the rate increase.

April Trunk Traffic Rise Brings Load Factor to Nine-Month High

Washington—Domestic trunkline traffic in April showed an upward swing which, coupled with a slight arrest in the volume of available seat miles pulled the industry load factor to 54.4%, its highest level since August, 1962, according to the Air Transport Assn.

Only Eastern Air Lines failed to register a gain in total passenger revenue miles. Six trunklines—Continental, Delta, National, Northeast, TWA and Western—reported increases of more than 14%. Western led the group with a 28% improvement.

The entire industry continued to cut back on first class available seats bringing the industry first-class load factor to 54%, a 4% increase over the previous April's load factor, and holding the decline of first-class revenue passenger miles to a slight 1.6%.

The trend toward coach travel continued unabated during April. However, to accommodate the demand for coach, the industry increased coach available seat miles by 21% during April, which outstripped the 15% gain in coach revenue passenger miles. Thus the load factor for this category of traffic dropped from 58% in April, 1962, to 54.8% last month.

The overall figures suggest that an overcapacity problem still exists although, if traffic increases continue during the next eight months, this problem could gradually correct itself.

Meanwhile, TWA President Charles C. Tillinghast called for a curbing of excessive flight scheduling. In an address in New York, he said:

"The examples of conspicuous over-scheduling are numerous as one carrier or another seeks to overwhelm his competitor by scheduling more flights. Although we jealously guard scheduling as a management prerogative and we always must, I believe the airlines should give serious thought to enlisting [CAB] support for concerted industry action to overcome some of the more flagrant examples of over-scheduling."

TWA showed a 15.2% increase in revenue passenger miles during April on its domestic routes, and international revenue passenger mileage set a new monthly record for the 10th consecutive month with a total of 93.4 million, a 26% increase over the previous April. The airline's recent comeback has attracted industry attention.

American Airlines had a 7% increase in revenue passenger miles, and showed a slight improvement in its load factor from 57.8% in April, 1962, to 58.4% last month. United Air Lines' traffic volume rose 4% but the over-all load factor dipped from 53.4% to 52.1%.

Despite a cutback in both coach and first-class available seat miles, Eastern's load factor dropped from 53% to 51.7% as a result of a decline in all categories of traffic reported by the airline.

American, Delta National, TWA and United each reported an increase in the volume of first-class revenue passenger miles, a decided reversal of industry trends during the past few years. These results suggest that first-class traffic may be leveling off and that diversion from first-class to coach may have slowed.

Western, however, continued to place emphasis on coach traffic as reflected by a 42% decrease in first class available seat miles and a 60% increase in coach seat miles during April.

How much effect the current rash of promotional fares had on traffic results during April was impossible to determine. Public statements by the airlines attributing traffic increases to their favorite fare structures only clouded the issue. For example, Continental cited its three-class fare structure as a boon to traffic growth and United was equally strong in praising its single-class service as a new traffic generator.

Chris Whelan, Continental's vice president-economic planning, had this to say on the economy coach jet class and the new business class fares:

"The stimulus the lower fare provided was extremely gratifying." He added that over Continental's Los Angeles-Chicago route, traffic in the last quarter of 1962 was 38% ahead of 1961's fourth quarter, and this growth continued in the first quarter of 1963.

On the other hand, R. E. Johnson, United's senior vice president-marketing and services, said last week that his company had improved its share of nonstop passengers flying between Chicago and San Francisco by 10% over last year in the two-month period the One-Class service has been operating. From Mar. 10 to May 10, he said, United carried 45.5% of the passengers flying the nonstop Chicago-San Francisco route, focal point of single-class service.

Continental reported a 26% increase in revenue passenger miles for April, and its low-fare classes showed a 63% traffic gain while first-class traffic fell 23%. The carrier's load factor rose from 45.4% to 49%. The airline's breakeven jet load factor is the lowest in the industry although National has become a strong contender in recent months.

National gained in all categories of traffic and reported a 23% increase in over all passenger revenue miles. Load factor rose from 53.6% to 56%.

Delta's load factor was the highest in the industry, 63%, the only one above the 60 mark. Its coach load factor was 67%, its first-class 56.9%. Only Northeast and American reported a higher first-class load factor. In April 1962, American had a 64% coach load factor but it toppled to 58.9% last month.

British Aircraft Corp. Develops Two New Versions of BAC 111

By Herbert J. Coleman

London—British Aircraft Corp. has designed two new versions of the BAC 111 twin jet transport which will provide additional power and payload using the basic airframe but converting to the Rolls Royce Spey 25 engines.

New BAC 111 versions, on which design work started last September and now is virtually completed, are designated the models 300 and 400. The basic BAC 111, the Model 200, is scheduled to make its first flight June 30 from Hurn, England, assembly plant.

Generally speaking there are no external changes between the basic Model 200 and the longer range versions except that nacelles to take the Spey 25s are 4 in. longer. There will be some strengthening at wing and stress points, however, to take the increased weights.

Metal is now being cut for the new models, and several will be phased into the production line soon.

Decision to stretch the range and payload followed conferences with airline officials who were interested in a short haul jet but one which also had the ability to fly medium distances if required. The Model 300, with a maximum takeoff weight of 82,000 lb. and payload of 15,600 lb. will fly stage lengths of 1,500 mi. with a full passenger complement.

The Model 400, which was specifically designed for the U.S. and Canadian markets, has a lower takeoff weight of 78,500 lb.—a payload of 15,400 lb. and less range than the Model 300. Company reasoning is that the U.S. is served by a number of larger jet transports already covering routes of 1,000 mi.

The Model 400 also will utilize a considerable number of major systems components of U.S. manufacture, and development studies involving alternate powerplants, such as the Pratt & Whitney JT8D-5, are continuing in the event of a possible customer requirement for this engine.

Fuel capacity of the new models is being increased from 2,640 U.S. gal. to 3,660 U.S. gal. by use of a center section tank. The tank now is being offered as an optional item on the basic BAC 111 to give it the same fuel capacity.

Ranges are 930 naut. mi. for the Model 200, 1,250 naut. mi. for the Model 300, and 920 naut. mi. for the Model 400. All three versions will carry up to 74 passengers and deliveries can be made by early 1965.

In designing the Model 400 for U.S. markets, A. J. K. Carline, chief of the design team, said the main object was to keep the weight below 80,000 lb. maximum gross weight. Lower weight would allow a two-man rather than three-man crew.

The modifications, aimed at making the BAC 111 a "LaGuardia Airport" capacity airplane are a larger capacity brake and installation of spoilers on the inboard section of the flap, used only at touchdown. Since the basic design was frozen in March, 1961, the only other modifications have been a change in the electrical system, minor changes in flying controls, and an increase in the tailplane area.

The three versions of the aircraft also will be offered with an autoflare and autoland capability, using the Elliot Bendix system. Carline said the Bendix PB 20D autopilot now is being packaged to make it suitable for integration with autoflare and with the capability to split the system for duplexing.

Flight control and hydraulic testing systems mockup now is being completed at the Vickers-Armstrongs plant at Weybridge. A fail-safe testing program involving a main fuselage and wing center section and an aft section plus tailplane is well advanced at Bristol Aircraft in Filton. The latter testing program is aimed at 100,000 flights and both units have been pressure tested to 15 psi, twice the design pressure.

The fail-safe program is based on a short- and medium-range standard flight plan, in that stresses are imposed on all phases of operation, from taxiing and turning to climb, cruise, letdown and approach loads. Basic test calls for five unpressurized load cycles on taxi and climb, with two pressurized load cycles during the cruise to landing phase.

Coach Section Movies

New York—Inflight movies previously shown only to the 20 first-class passengers on Trans World Airlines' 17 transatlantic jets will be expanded to the 120 seat economy section on May 29.

TWA officials stress that the movies were originally designed for the economy traffic aimed at the mass appeal. However, they were shown initially in first class as another feature of **TWA's** Royal Ambassador service, a high quality food and beverage program designed to meet the service offered by foreign carriers.

Economy travlers will be charged $1 for use of the headsets which carry the sound track; the charge required under **IATA** restrictions on how much free service can be afforded under economy fares.

Frontier Airlines Pushes Sales Campaign

Denver—Frontier Airlines, serving an area that accounts for only 2% of the nation's population, is developing sales and promotional campaigns designed to lure traffic from outside the sparsely settled 11-state region in which it operates.

Frontier's routes run generally north and south from Montana and North Dakota to Arizona, New Mexico and the northwest tip of Texas. The carrier serves many isolated communities that need air transportation but are unable to generate sufficient traffic to justify air service. The problem has been to explain to civic leaders how the cold facts of the Civil Aeronautics Board "use-it-or-lose-it" policy can be overcome. In addition, Frontier had to find means to attract traffic from other sources to give the carrier a profit.

The problem was compounded by a previous management policy, developed under L. B. Maytag, Jr., once Frontier's president and now head of National Airlines, which called for eliminating all unprofitable services. Maytag's goal was a regional type of operation and his drive for profits at the sacrifice of unproductive services created much ill-will throughout the Frontier system.

In April, 1962, Lewis W. Dymond, left as National's operations vice president to take over Frontier's presidency after Maytag sold his Frontier holdings to Goldfield Consolidated Mines Co. Maytag purchased G. E. Baker's National stock and became president of that airline. Although the operating policies of Maytag and Dymond are poles apart, both carriers profited by the move (AW May 6, p. 42).

Dymond and C. M. Britt, who was brought in last year as vice president sales and services, immediately set out to restore good relations with cities served by Frontier. The two began a series of visits with state, civic and business leaders throughout the carrier's 5,800 mi. of routes to promote Dymond's basic principle: "The purpose of a local service carrier is to provide the best possible service to all communities it has been entrusted to serve."

The effort was a success, notably in Nebraska, where rancor had run particularly strong. One newspaper, which had consistently lambasted Frontier under the old regime, recently made this editorial comment: "We must put up or shut up. The burden of proof is up to us."

Other newspapers took a similar stand and the response was immediate. In March, Frontier's passenger traffic in Nebraska cities rose 62% over the volume carried in the previous March. First quarter of 1963 was the most profitable quarter in the airline's 17-year history. Operating profits were $373,230, compared with $32,719 in the same period last year. Net profit was $181,420, compared with $72,721 for the first quarter of 1962.

Operating efficiency has been the key to the growing profit margin. Seat mile costs of the airline's 11 Convair 340 fleet were reduced from 5.6 cents to 4.7 cents in the first quarter of 1963. Aircraft utilization was increased from 6 hr. to 8 hr. 5 min., an especially high rate since the airline operates no late night schedules. Direct operating costs of the Convair dropped from 91 cents per mile to 78 cents per mile in the first quarter.

Time out of service for the complete overhaul of a 340 has been cut from 30 days to 18 days. Down time for a major inspection has been sliced from 18 to 7 hr.

Recognizing that the volume of business traffic available in its region is not high enough to boost revenues, the airline elected to look elsewhere for new markets, particularly in the heavily populated areas of the east. To attract this market, Frontier developed a vacation area fare of $100 which permits unlimited travel on its system for 30 days. Children under 12 traveling with parents may fly under the plan for $50.

The fare applies to travelers from the eastern half of the U. S., Hawaii, Alaska and overseas. Its value lies in the fact that six national parks are located on Frontier's routes.

Here are some other fare innovations Frontier has introduced since Dymond and Britt took over:

- **Family plan fare.** Wife, traveling with head of the family, pays half-fare, children one-quarter fare. Between Nov. 10, when the plan was inaugurated, and the end of March, 15,938 passengers had purchased tickets under this plan.
- **Round-trip 30-day excursion fare.** Sold at substantial discounts to resort areas on Frontier's system.
- **Group travel plan.** Free ticket is given to one person traveling in a group of seven or more.
- **Youth fare.** Half fare for students and military personnel under 22 years of age. To qualify, traveler purchases a $5 age identification card good at all times. As of Mar. 31, 5,800 cards had been sold, giving the airline an additional $29,000 in revenues. Total revenues from this source of business had reached $222,000 by the end of March.

Frontier's improved position has prompted hanks to drop the U. S. government guarantee on its long-term loans which relieves the airline of certain restrictions and, in view of recent Board action against the purchase of jets by local service airlines with guaranteed loans (AW Mar. 4, p. 34), may give it a freer hand in developing a jet program.

In December, Frontier refinanced its long-term debt and was granted a line of credit of $3.5 million at 5¾% interest. Proceeds were used to retire a previous loan of $2.4 million, at 5¾%, and to finance the purchase of four additional Convairs.

Dymond intends to adhere to his policy of maintaining service to cities within the Frontier system. He has requested the CAB to defer action on the possible curtailment of service at several points in Nebraska, South and North Dakota and Montana on grounds that traffic can be developed in these areas. An agreement to transfer certain routes in Montana to North Central Airlines has been allowed to expire and Dymond intends to press for renewal of these routes before the CAB.

FRONTIER AIRLINES Convair 340 is shown loading passengers at Jackson, Wyo.

Locals Define Transport Aircraft Needs

Ft. Worth—Airframe manufacturers were briefed here on operating parameters for a low-cost, short-haul transport carrying 18 passengers at speeds of more than 300 mph. Assn. of Local Transport Airlines believes such an airplane can be developed within five years and will aid materially in maintaining a two level airline system in this country.

Allegheny Airlines President Leslie O. Barnes, chairman of the ALTA low-cost airplane design committee which was formed late last year to develop requirements for the new airplane (AW Dec. 24, p. 28), briefed 20 manufacturers' representatives on the committee's recommendations at the conclusion of ALTA's spring meeting.

He stated that the committee was being dissolved and would be replaced by a new technical committee that will develop the program in greater detail, invite airframe manufacturers to submit proposals for analysis and make recommendations to ALTA on comparative evaluations of the proposals.

Initial reaction by manufacturers' representatives at the conclusion of the briefing was that there was little likelihood that any existing airplane would be capable of performing the mission requirement outlined. They felt that the project required maximum utilization of engineering state-of-the-art technology.

Barnes noted that the project hinged on two vital considerations:

• A "go-slow" policy must be followed by the Civil Aeronautics Board in its application of the use it or lose it policy, which requires generation of five passengers per day per point served and seven passengers per mile operated over a given route and in the area of subsidy reduction. ALTA contends that there is a conflict in earlier desires by Congress that smaller cities be included in the national air transportation plan and the call by the executive branch for rigorous application of the CAB policy aimed at reducing operating subsidies. Further reduction in subsidies would make it unlikely that the local service airlines could afford the new airplane.

• **Substantial development funds** must be assured for the new project. Best estimates are that the new airplane sought by ALTA would require more than $20 million for research and development including building of approximately five prototypes. Few manufacturers would be willing to gamble this amount and most or all of the bill probably would have to be picked up by the government. For a manufacturer to become involved in such an investment would probably mean pricing the airplane beyond what local service airlines feel they could pay and would also drive the direct operating costs up beyond their target figure. The ALTA committee hopes for a price of about $400,000.

Basic specifications outlined by Barnes in his presentation included:

• **Seating capacity** for 18 passengers and crew of two, plus luggage and an additional 1,000 lb. of cargo. The cockpit would be designed to permit full and convenient operation of the airplane from either pilot position. An 18-passenger airplane, the committee contends, cannot afford the luxury of a cabin attendant and one of the pilots would be required to leave the cockpit to go into the cabin in an emergency.

The design must take into account that at many stops the pilot and co-pilot will be required to help load and unload passengers, handle weight and balance control and paper work for passengers, cargo and mail transfer.

• **Operating cost objective** of 40 cents per statute mile, which the committee admits is "substantially below" that which has been achieved to date. It has considered flight crew costs of $22.53 per block hour, which includes salaries for the two-man crew, benefits, training and crew expenses. A cost of 13.5 cents per gallon for turbine fuel is assumed, with tax and service cost.

Manufacturers will be encouraged to construct cost estimates for maintenance and overhaul, based on the service schedule proposed by themselves, their engine manufacturers and component manufacturers. The committee considers average rates per man-hour of labor to be $3.00 per hour, and manufacturers will be requested to document in detail the basis for their service schedules.

Manufacturers will also be asked to specify plans for spare parts provisioning and estimates of spare parts per aircraft for fleets of specified sizes. Depreciation of fully equipped aircraft, plus spares, will be considered over seven years to a 10% residual value.

Annual hull insurance premium would be computed on the basis of 3.5% of the value of a fully equipped aircraft. Passenger service costs will be computed at two cents per plane mile, assuming a 50% load factor.

Calculation of cost elements will be based on an average stage length of 80 stat. mi. and a utilization of six block-to-block hours daily.

• **Operating range** would be 500 stat. mi. nonstop with full payload and necessary fuel reserves. The committee noted that the airplane was being considered as most useful over 80-mi. stage lengths, but that there would also be a requirement for longer stages. The ability to accommodate three intermediate stops and still achieve the 500-mi. non-refueled range, would be a "positive asset" in the ultimate selection.

• **Runway length** of 3,500 ft. maximum for takeoff and landing under applicable Civil Air Regulations for sea level hot day conditions with full payload is considered an objective for the proposed transport. A high-speed taxi capability is considered important to minimize ground time.

• **Approach speeds** requirement considers an airplane stable and easily controllable with a maximum stalling speed under standard sea level conditions of 60 mph. Barnes said ALTA considered low approach speeds necessary in order to require less in the way of landing aids at small airports and to make possible operations at lower minimums than aircraft of higher landing speeds.

• **Maintenance and overhaul** times of 300 hr. for inspections of aircraft structures, systems, engines and accessories and 5,000 hr. between overhauls.

• **Cruise speeds** exceeding 300 mph.

• **Maximum landing weight** identical to maximum takeoff weight. This would eliminate paperwork on the part of the crew as well as to provide for full payload utilization on short flights.

• **Pressurization** should be considered in the design. Some customers may wish deliveries of unpressurized versions, but the basic airplane should have the capability for readily taking pressurization equipment, should it be specified. Aircraft should be completely self-sustaining away from home base. Airstair-type doors, engine starting and other services should be considered, as should the capability of discharging and taking on passengers, cargo and mail without shutting down any engine or systems.

A six month development program is considered by the committee as necessary to bring forth a design production plan for the most effective airplane.

CAB Role

Ft. Worth—Civil Aeronautics Board may be confused as to the role Congress expects it to assume, Rep. Walter Rogers (D-Tex.) said here at a banquet meeting of the Assn. of Local Service Airlines.

It might be well, he said, if Congress could state a policy to the effect that the air transportation system is a national problem and must be treated as a single problem.

Rogers said it would be disastrous for the local service lines to slip backward into poor financial conditions and to try to cure such an ailment by further curtailment of service to thinly populated areas.

Turbine Aircraft—1962 Operating Costs, Cents Per Mile

	Total Miles (000)	Flying Operations	Direct Maintenance	Sub-Total	Depreciation	Total Direct Expense	Applied Maintenance Burden	Total Aircraft Expense
BOEING 707								
Pan American	58,265 6	99 43	33 45	132 88	39 56	172 44	24 00	196 44
Trans-World	56,701 8	86 68	28 85	115 53	34 04	150 37	19 37	169 74
American	34,615 5	80 56	38 75	119 31	35 81	155 12	33 81	188 93
Continental	8,729 9	85 92	32 25	118 17	25 89	144 06	13 77	157 83
Braniff	4,883 2	94 82	32 01	126 83	39 98	166 81	12 27	179 08
Western	2,173 4	138 41	31 69	190 10	10 50	200 60	7 79	208 39
707 Average	27 561 9	91 04	32 85	123 89	36 06	159 95	23 37	183 32
DOUGLAS DC-8								
United	59,770 5	84 54	26 89	111 43	31 26	142 69	22 37	165 06
Pan American	31,299 9	115 14	38 54	153 68	42 21	195 89	30 37	226 26
Eastern	18,348 5	116 72	33 79	150 51	37 47	187 98	15 85	203 83
National	12,321 0	104 54	33 17	137 71	27 94	165 65	12 94	178 59
Delta	10,971 5	98 41	37 94	136 35	49 61	185 96	23 17	209 13
Northwest	8,045 6	107 12	31 49	138 61	38 96	177 57	15 18	192 75
Panagra	2,616 6	120 61	91 35	211 96	46 06	258 02	4 92	262 94
Trans-Caribbean [1]	1,814 9	89 44	51 24	140 68	36 44	177 12	8 43	185 55
DC-8 Average	18,148 6	99 91	33 37	133 28	36 27	169 55	21 64	191 19
BOEING 720								
United	35,495 0	83 17	20 95	104 12	22 84	126 96	18 33	145 29
American	34,433 3	80 72	36 34	117 06	34 48	151 54	31 45	182 99
Eastern	16,336 8	127 08	27 01	154 09	14 03	168 12	11 38	179 50
Northwest	14,040 2	94 13	30 16	124 29	29 19	153 48	14 30	167 78
Western	7,100 2	89 71	42 98	132 69	31 84	164 53	9 36	173 89
Continental	4,122 2	75 97	24 30	100 27	28 79	129 06	9 52	138 58
Braniff	4,097 2	69 20	29 87	119 07	32 55	151 62	9 81	161 43
Trans-World	4,064 7	152 81	26 08	178 89	13 93	192 82	21 01	213 83
Pacific Northern	1,748 5	102 86	34 49	137 35	33 18	170 53	12 75	183 28
720 Average	13 493 3	92 61	29 26	121 87	26 60	148 47	19 54	168 01
CONVAIR 990								
American	7,579 6	99 18	41 75	140 93	42 32	183 25	32 76	216 01
CONVAIR 880								
Trans-World	24 053 2	82 82	48 99	131 81	39 05	170 86	25 59	196 45
Delta	18 496 6	83 21	35 82	119 03	32 68	151 71	19 55	171 26
Northeast [1]	7,781 0	144 23	60 15	204 38	3 73	208 11	25 42	233 53
Alaska [1]	1,350 1	118 13	33 41	151 54	18 77	170 31	9 46	179 77
880 Average	12 920 2	93 13	45 55	138 68	30 92	169 60	22 98	192 58
SUD CARAVELLE								
United	14,217 1	74 65	34 89	109 54	47 35	156 89	25 90	182 79
CANADAIR CL-44								
Flying Tiger	9 779 8	79 15	62 59	141 74	43 07	184 81	15 53	200 34
Seaboard	5,714 4	92 86	58 91	151 77	42 47	194 24	21 63	215 87
Slick	2,235 1	79 47	50 00	129 47	44 77	174 24	8 64	182 88
CL-44 Average	5 909 8	83 61	59 82	143 43	43 09	186 52	16 63	203 15
LOCKHEED ELECTRA								
Eastern	20,612 6	66 39	41 76	108 15	56 47	164 62	15 77	180 39
American	19,824 2	64 99	54 45	119 44	45 81	165 25	21 03	186 28
Northwest	12,338 0	68 33	33 42	101 75	32 87	134 62	15 60	150 22
Western	10 379 3	53 79	41 90	97 69	41 56	139 25	7 19	146 44
National	10,269 4	60 92	36 90	97 82	23 71	121 53	12 63	134 16
Braniff	6,740 1	57 53	45 96	103 49	24 52	128 01	11 43	139 44
Electra Average	13,360 6	63 52	43 36	106 68	41 39	148 27	15 17	163 44
FAIRCHILD F 27								
Bonanza	5,677 9	41 28	24 29	65 55	11 81	77 36	6 34	83 70
West Coast	3,978 4	48 43	28 17	76 62	9 13	85 75	5 87	91 62
Fredmont	3,830 6	48 54	28 82	77 36	13 04	90 40	9 70	100 10
Pacific	2,485 8	50 33	31 13	81 46	15 99	97 45	13 59	111 04
Alaska	2,329 7	46 12	29 99	75 11	18 43	93 54	12 24	105 78
Ozark	1,693 5	43 96	33 86	79 82	10 88	90 70	11 57	102 27
Nor. Consolidated	953 0	61 46	36 08	97 54	16 97	114 51	18 93	133 44
Wien Alaska	715 0	59 27	30 64	89 91	15 58	105 49	19 40	124 89
F-27 Average	2,695 5	47 28	28 57	75 85	13 02	88 87	9 73	98 60
VERTOL 107								
New York	256 7	142 09	142 23	284 32	49 15	333 47	59 63	393 10
SIKORSKY S-61								
Los Angeles [1]	200 4	110 44	64 66	175 10	68 42	243 52	26 25	269 77

[1] Data is for year ending Sept. 30, 1962.

Prepared by Ray & Bay

1 Spey engines have been delivered for the first B.A.C. One-Eleven.

2 The Spey has completed nearly 10,000 hours development running, including 2,900 flying hours.

3 The Spey has been ordered by 8 different customers in 5 countries, including 6 air lines.

The Spey is winning world acceptance

Production engine deliveries of the Spey are building up fast. And more and more airlines are showing firm interest in the engine for their re-equipment programmes.

In its design and rating the Spey is based on Rolls-Royce's unique experience of commercial turbine operation. This is your assurance of the operational economy vital for profitable use of the short-haul jet.

The Spey will bring to jet travel all the inherent qualities of the Dart.

A NEW PHASE BEGINS WITH ROLLS-ROYCE POWER

ROLLS-ROYCE OF CANADA LIMITED, 6265 COTE DE LIESSE ROAD, MONTREAL, P.Q.

AIRLINE OBSERVER

▶ Air France interest in the Concorde supersonic transport may bring an end to plans for the organization of Air Union. Although French participation in the consortium has been given the personal approval of President de Gaulle, Air France now wants to be in a position to introduce the Concorde on its routes without any obligation to other members of the proposed combine—Alitalia, Lufthansa and Sabena.

▶ **Air Transport Assn. has notified the Federal Aviation Agency it will oppose an FAA requirement that U. S. airline transports be equipped with distance measuring equipment (DME). ATA said that because the rule excludes military and other civil aircraft, full safety advantages of DME cannot be realized.**

▶ Rolls-Royce is conducting bird ingestion tests on the Conway bypass engine series under Ministry of Aviation contract. Results so far show the Conway can ingest up to 16 starlings of 2-4 oz. each simultaneously with insignificant effect on engine performance and no damage to components. Thrust loss was 1 to 2% and engine continued running for 5 min. at maximum power, followed by 55 min. at settings covering maximum climb, cruise and descent.

▶ **FAA Administrator N. E. Halaby last week briefed an Administration Cabinet Advisory Group on the proposed U. S. supersonic transport program. The group will present the program to the President after studying the plan. Emphasis is being placed not so much on speed but on whether the aircraft can be operated economically. Goal is to build an airplane with at least 10% of its gross weight represented by payload, although 8% appears to be the maximum at present. Hope is to build a transport that will carry about 150 tourist passengers on a transatlantic flight.**

▶ United Air Lines last week stated that One-Class Service flights have been operating at a load factor of 64% since the service was inaugurated Mar. 10. The figure excludes overnight flights which, the airline said, are operated primarily for cargo purposes. United added that more than 55,000 passengers have used the service and that 85% of those surveyed indicated they were "pleased" with the service.

▶ **KLM, the Royal Dutch airline, has cut the work week for U. S. ground and maintenance employes from 37½ to 35 hr. New contract with the Transport Workers Union provides hourly pay increases ranging from 29 to 54 cents with time and a half overtime pay after the 35-hr. week and double time after 11 hr. a day. KLM ground personnel elsewhere received a 2.7% pay increase.**

▶ Pacific Southwest Airlines was scheduled to take delivery this week of the last unsold Electra turboprop transport still remaining in the inventory of Lockheed Aircraft Corp. The aircraft was completed in May 1960, never went into service and will be delivered to PSA with no operating time on it. Financial arrangements with two earlier prospective purchasers—Capital Airlines and a charter company—had failed to materialize. The plane will increase PSA's Electra fleet to six.

▶ **Next major trunkline route case to be undertaken by the Civil Aeronautics Board may be a route from the middle south and southwest U. S. to the Pacific northwest. Need for such a route stems from decentralization and expansion of space and electronic industries (AW May 6, p. 42).**

▶ Local service carriers reported a 17.2% increase in revenue passenger miles for April over the same month last year, but a comparable gain in available seat miles kept the industry load factor static—43.6%. All but two carriers—Pacific and West Coast—showed substantial traffic increases with Piedmont, Frontier and Bonanza reporting the biggest improvements.

▶ **Delta Air Lines Vice President R. S. Maurer has forecast an annual traffic growth for the air transport industry through 1975, of 8 to 10% if the economy of the nation remains strong. FAA has forecast a 6.7% annual increase for the same period.**

SHORTLINES

▶ **Allegheny Airlines** reported a net loss of $203,957 for the first quarter of 1963, compared with a $110,919 loss in the same period last year. Revenues gained in the first three months, however, and the airline anticipates year-end profits comparable to $1962's net earnings of $631,000.

▶ **American Airlines** had a 4% increase in airfreight volume handled during the first four months of 1963, compared with the same period last year. The airline handled 49.1 million ton miles of airfreight during the first third of 1963.

▶ **British European Airways** has purchased two Sikorsky S-61 helicopters at a cost of $700,000 for service on the Lands End-Scilly Isles route.

▶ **Sabena Belgian Airlines** has opened an "Aerohotel" for use of transit passengers at Brussels National Airport. Sleeping facilities were installed as a result of the increasing number of business men entering Brussels in connection with the Common Market.

▶ **Capitol Airways** has opened a European sales office in Paris in a move to expand group passenger charter business originating in Europe.

▶ **Emery Air Freight Corp.** reports that the number of shipments handled for the aviation industry during the first quarter of 1963 increased 85% over the same period last year.

▶ **KLM Royal Dutch Airlines** will open six new sales offices in the U. S. as part of a new campaign to provide better service to travel agents. The expansion program will increase the number of KLM sales offices in the U. S. to 36.

▶ **Northwest Orient Airlines** will add an eighth weekly jet round trip to its present daily transpacific jet service. New flight will operate on Saturdays from New York to Chicago, Anchorage, Tokyo and Manila.

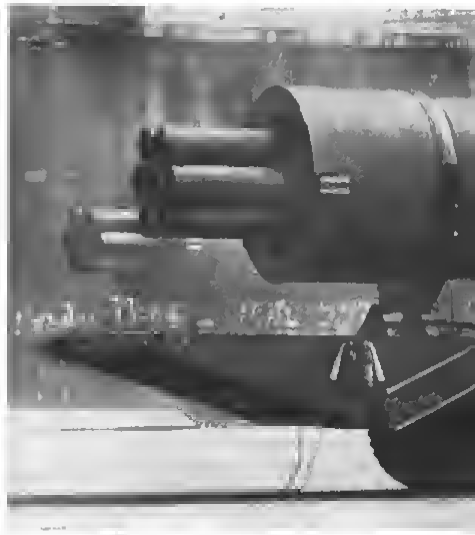
▶ **Pan American World Airways** has signed an agreement with Japan Air Lines under which 15% of the space on each of Pan American's airfreight transpacific flights will be allotted to the Japanese flag carrier.

▶ **United Air Lines** showed an increase of 6% in passenger revenue miles for April, compared with the same month last year. The carrier flew 1,119,414 passengers 710.7 million passenger miles.

Soviets Display Missile Arsenal in Moscow

Soviet Navy's submarine-launched ballistic missile, code-named Snark by NATO, carries serial number 6 2 86 in large numerals during May Day parade in Moscow. Red Navy personnel carrier and tow vehicle is the same as that used in Snark's first display last Nov. 7, but Snark transporter shows considerable refinement indicating a production version. Platform structure at the aft end in the earlier version is missing, and design of the aft section now appears to provide a base for elevation of the carrier with the rear wheels as pivot point. Supporting structure at all three mounting points also has undergone modifications and the rods at the second stage are an addition. (AW Nov. 26, p. 34) Second Snark, numbered 6-2-89, is partly visible in the background.

Warhead and upper stage section of Snark is shown in detailed closeup. Tucks near clamp at the base of the re-entry body indicate a cloth is used as a protective cover. Note deep tread, heavy duty tires. Two pairs carry the forward section, and four pairs the aft.



Close-up of the aft section of Snark shows detail of cluster at base. This may be a driving plug for underwater ejection, the manifolded cluster containing propellants for gas generation. Fire extinguishers, grounding lines are uncommon on Soviet missile transporters.

Side view comparisons of the Soviet SA 2 Guideline (above) and the SA-3 (next page) emphasize design differences in the two anti-aircraft missiles. Estimated length of Guideline is about 35 ft., and the SA 3 is slightly longer and larger in diameter. Booster stage on Guideline is equipped with four large fins, two with control surfaces, and four cruciform control fins are mounted on the main stage aft of the main wings. SA 3 has a single set of four canard control surfaces and two of the four main wings have a stub antenna or probe mounted at the tips. Many of the men manning the SA 2 and SA-3 vehicles wore Red Air Force uniforms at the display this year. This could mean a shift in missile command responsibilities even though the Soviet minister of defense, Marshal R. Y. Malinovsky, is known to favor a large standing army. One of several versions of the Frog tactical missile is visible in transporters at right (above). Electrical lines or cables that extend from fairing behind the control fin on Guideline's main stage are seen only on this side of the missile (above). The lines cross to the booster section by means of a small support projecting from the booster stage.

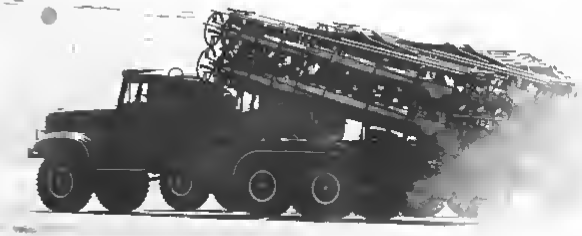
Rear view of SA 2 shows centerbody in the nozzle booster. Configuration resembles a plug nozzle, but value of such a technique in an anti-aircraft missile with an altitude capability estimated at 80,000 ft. is unclear. Four small, square notches, approximately in line with each fin, are cut in the skirt of the nozzle.

Transporters for SA-2 (p. 54) and SA-3 are not the same, but the truck sections are similar. SA-2 carrier has a single transverse mounted compressed air tank at the forward end. SA-3 carrier has tanks mounted lengthwise on each side at the center of the transporter. Nozzle cover for SA 3 splits horizontally and fasteners are visible (below). Note control surfaces on two of the four main wings of SA 3 (AW May 13, p. 32) and the stub antenna or probe on the wings without the control surfaces.

Soviet Shyster medium range ballistic missile, with serial number 485445, was displayed in parade with the later version, designated Sandal (in background and top of p. 57). Sandal, which was deployed in Cuba, has flared skirt, smaller fins. Sandal in parade carried the serial number 832748. Transporter for Sandal is similar to Shyster's, but is longer and shows detail modifications.

Light high speed tanks in the van of the parade are marked with the insignia of the Russian Army's airborne units. They followed a small group of paratroops in full combat gear.

Launcher for battlefield rockets (right) probably spins the missile in launching to provide stabilization and reduce dispersion at the target. Smoke coming from the engines of the transporters is heavy enough at right to obscure rear of the launchers. Large long range antiaircraft and bombardment field guns (below) were mounted on tank chassis as self contained units.



Mars Mission Equipment, Vehicles Studied

By Irving Stone

Los Angeles—Series of studies to establish design and operational requirements for manned missions to Mars during favorable and unfavorable periods extending through 1985 is being implemented by National Aeronautics and Space Administration.

Requests have been issued to industry for proposals, all due this month, relating to these mission facets:

- **Mars landing and reconnaissance** mission environmental control and life support system study (cognizance of Manned Spacecraft Center).
- **Mars mission-module** subsystems study (MSC).
- **Mars-mission** earth-re-entry module (MSC).
- **Mars exploration** in the unfavorable (1975-1985) time period (Marshall Space Flight Center).

Work statement for the environmental control system study reveals that the Mars mission will span 420 days including 140 days to establish the Mars orbit, 40-day stay on Mars, and 240 days for return to earth.

Three Modules

The Mars vehicle is projected to include three structural modules—mission command, and a two-stage Mars landing module, designated the Mars excursion module (MEM).

The vehicle normally would be designed to support three crew members, but would be required in an emergency to accommodate a crew of six.

Mars mission is projected to involve the use of two vehicles to ensure against mission abort in the event of failure of one of the vehicles during any phase of the expedition. In an emergency which caused the crew to abandon one of the spacecraft, the command module would be used to rendezvous with and transfer the crew to the other spacecraft.

Modules will include:

- **Mission module** will be the primary living quarters of the Mars vehicle. Its environmental control system also would support the command module when the modules are mated.

Mission module volume will be 4,500 cu. ft. and will utilize a nuclear power source for its environmental requirements.

Mission and command modules both will operate in a variable gravity field up to 0.6g, but their subsystems will have to be capable of functioning in a zero gravity environment.

- **Command module** and its environmental control system will be designed to withstand a two-day earth-re-entry phase under normal conditions, after the mission module has been jettisoned.

The command module will be required to support the peak crew of six during earth re-entry or the normal crew of three for three days during an emergency rendezvous.

Volume of the command module will be 320 cu. ft., which will provide space for the Mars mission crew during vehicle launch as well as during earth re-entry.

Auxiliary chemical power unit will support the command module when its operation is independent of the mission module.

- **Mars landing**, or excursion, module will be jettisoned from the mission module during the Mars orbit, will land three astronauts on the surface of the planet, support them for a maximum exploration period of 40 days, then return the astronauts to the orbiting vehicle.

Landing module will have a volume of 1,000 cu. ft. and probably will use a small nuclear reactor as a power source for support services.

Environmental control system will have to satisfy these metabolic requirements for the mission and command modules—1.8 lb. per man-day for oxygen consumption, 1.0 lb. per man-day carbon dioxide output, 6.16 lb. per man-day of water consumption, and 11,200 BTU per man-day heat output.

Corresponding figures for the landing module will be 2.2, 2.5, 9.00, and 14,400.

Cabin pressure will be maintained at a nominal value of 7 psia., with oxygen partial pressure controlled to about 3.5 psia.

Nitrogen will be utilized as the diluent gas. If this arrangement involves a significant weight penalty or system complexity in either the command module or the landing module, the requirement for the two-gas system may be relaxed.

Water Reclamation

Other requirements include a cabin temperature of 70 ± 5 deg., cabin relative humidity within 30-70% range, and thermal control for equipment, with critical equipment not dependent upon cabin atmosphere for cooling or pressurization. Thermal control would be accomplished with a heat rejection system for the cabin, equipment, and experimental apparatus.

Water management would involve provisions for reclaiming potable water from wash water, urine, and other contaminated supplies. A method for dissociating water to form oxygen and hydrogen will be considered as part of the oxygen reclamation systems. Water also would be collected from the atmospheric conditioning loop and stored for future use.

Waste management program will involve methods to be used for storing, dehydrating, and/or reclaiming solid waste products.

Mars mission module subsystem study will involve a failure effects analysis, a reliability analysis based on the failure analysis and an abort-mode design for the vehicle. The Mars vehicle configuration and mission profile to be used in the study will be furnished to the contractor by NASA's Manned Spacecraft Center.

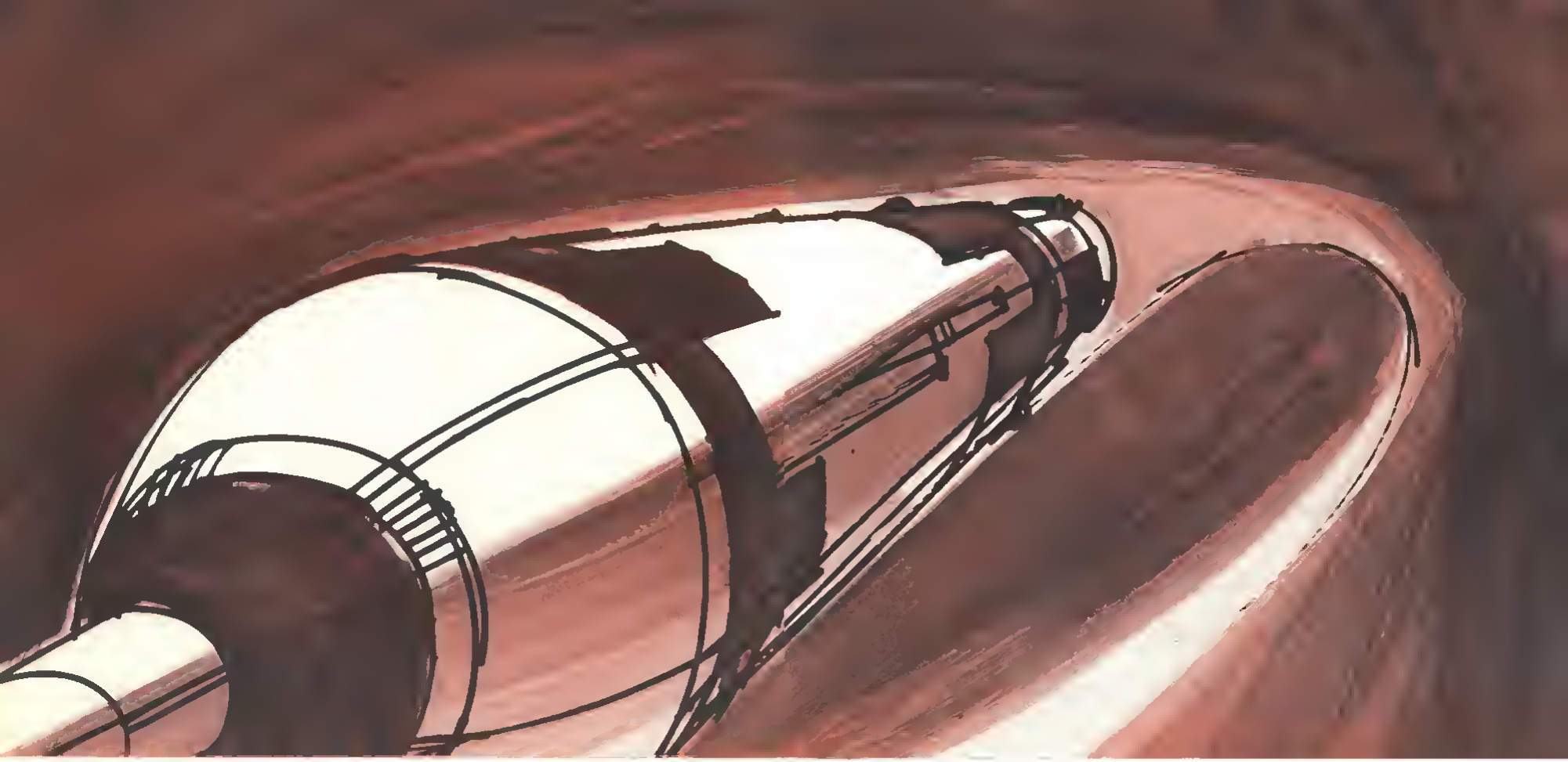
Decision on equipment to be developed will be held to a reasonable state-of-the-art advancement and availability.

Mars Landing Missions

Studies programed by National Aeronautics and Space Administration for manned Mars missions during the 1970-1985 period will cover spacecraft command, living and excursion modules, together with related requirements.

Industry proposals are being submitted this month, for the following efforts:

- Manned Mars mission-module subsystem study. Proposals are due May 20, for this six-month effort, which will not exceed $100,000.
- Mars mission earth-re-entry module preliminary design effort. Proposals are due May 20, for six-month task, not exceeding $150,000.
- Mars landing and reconnaissance mission environmental control and life support system study. Proposals were submitted May 9, for six-month effort.
- Manned Mars exploration in the unfavorable (1975-1985) time-period study. Proposals were submitted May 3, for 6,500 engineering man hour, seven month task.



Thrust vector controls... from the people at Bendix

Techniques of steering rocket engines are a specialty of Bendix people. We pioneered in movable exhaust nozzles. We are in production on secondary injection systems. We are developing solid probe thrust vector controls. ☐ Other people at Bendix are working on rocket equipment, high temperature composite materials, nuclear mechanisms, propulsion controls and landing gear for both aircraft and space vehicles. An Aerospace team of skilled and experienced people . . . skilled in all phases of program management, backed up by complete engineering and production facilities . . gives Bendix the capabilities to undertake many varied Aerospace programs. ☐ To find out what this Bendix team can do for you, write. General Sales Manager, South Bend 20, Indiana.

Bendix Products Aerospace Division

THE Bendix CORPORATION

for Mars space flights in 1970 to 1973 and in 1973 to 1978. Assumption is that the first complete system flight with all modules will be the actual manned Mars space flight and flight worthiness will be emphasized.

Subsystems will be designed, and repair equipment included to provide a capability to repair an on-board subsystem although few such occasions are anticipated. Weight limitations or repair time involved for a specific system may eliminate the on-board requirement for a specific subsystem. Redundancy may be considered in some instances to minimize the repair requirement.

The Mars excursion module (landing module) and the earth re-entry module (command module) will be designed as separate tasks and integrated with the design of the mission module by MSC.

Mission Module

Subsystem effort for the mission module will involve these requirements:

- **Guidance and navigation system** will provide capability for a stable reference and a computer function to store programmed trajectories from launch to return. Computer will have to be capable of supporting a search for the best trajectory based on current-position data with tradeoff presentations for propellant usage, time, and use of expendables, coupled with a summation of best action probability of mission success or safe return to earth.
- **Flight control system** will provide a complete manual and automatic flight capability from liftoff to earth return.
- **Data transmission system** will provide voice and telemetry contact with earth and the Mars excursion module, and intercom service on the mission module. Provision will be incorporated for data storage and manual and automatic readout and transmission to earth and the Mars excursion module.

The system also will provide tracking capabilities to establish position-time data relative to objects near the planet such as satellites, and afford fine resolution for rendezvous and docking maneuvers with the excursion module.

Provision also will be incorporated for radio spectrum mapping of star radiations. Infrared and ultraviolet spectral ranges may also be included.

- **Structures system** will incorporate shielding and allow for a reasonable selection of equipment for stowage in the mission module. The structure and its configuration will incorporate a load-bearing capability based on the assumption that the earth-re-entry module (command module) is the top unit in the flight vehicle configuration.

Earth re-entry module is expected to weigh not more than 15 000 lb., which will be about one-third the total weight of the Mars spacecraft in the earth Mars trajectory.

Mars Studies

Supplementing the Mars manned mission studies sponsored by the National Aeronautics and Space Administration's Manned Spacecraft Center and Marshall Space Flight Center are two analyses under the cognizance of NASA's Ames Research Center. These will be performed by North American Aviation's Space and Information Div. and Space Technology Laboratories.

The Ames' contracts, each $100 000, provide for nine month investigations to:

- Determine requirements for possible Mars missions.
- Decide what research will be required in the next several years to make such missions possible.

The Ames' projects will be purely analytical are expected to produce estimates of such elements as spacecraft weight, booster requirements and interplanetary trajectories.

Key areas to be explored in the earth-re-entry module study include:

- **Trajectory dynamics** and heat transfer for entry at speeds corresponding to return from typical Mars mission for 1971, 1973, and 1975. Re-entry will have to be accomplished without the use of retrograde rockets.
- **Re-entry profile** will be delineated in detail.
- **Most promising module** configuration and interior arrangement within existing state-of-the-art will be established. The re-entry module will have to be self sufficient with respect to supplies, expendables, etc.
- **Type of heat protection** and major structural system will be defined.
- **Best control technique** for the vehicle will be determined, together with most desirable method of information display for the crew during re-entry.
- **Major subsystems** will be defined with respect to weight, power requirement, volume, etc.

Mission Profiles

Purpose of the study for manned Mars exploration in the unfavorable time (1975-1985) period is to survey all attractive mission profiles, with main criterion being the minimization of initial mass in earth orbit. Identification of problem areas which appear capable of solution also will be investigated.

The manned Mars landings anticipated for the study also will use an orbital operation at Mars involving a Mars excursion module (MEM).

Guidelines established for the study indicate that missions will start from a 200 mi.-altitude earth orbit.

Major part of the study effort will be related to high-acceleration (more than 0.1g propulsion system). Low-acceleration propulsion systems will be considered only as one of the means to alleviate conditions of the more difficult missions.

Manned flight to Mars will be relatively easy around 1971, relatively difficult around 1979.

All critical systems, such as propulsion structures, life-support, aerodynamic braking, and shielding will have to be compatible with the expected state-of-the-art at the proposed time of usage, 1975-1985. Where this compatibility is not obvious, development programs will have to be outlined. When Mars landing missions are not practical during the difficult time period, missions such as a Mars orbiter or Mars flyby will be considered.

Study Results

Results expected from the study will include:

- **Determination of requirement** for a manned Mars mission is a function of 10 to 50 days of stay time, and a total duration of 1 to 3 years. Aspects to be investigated will be concerned with direct launch from earth orbit, rocket or aerodynamic entry into a satellite orbit around Mars and launch from this orbit, and direct aerodynamic entry or combined rocket-aerodynamic braking on return to earth.
- **Payload requirements,** including radiation shielding, for crew complement of 3 to 10 men.
- **Trajectory optimization and shaping,** with respect to extreme solar distances and sensitivity coefficients such as launch windows.
- **Conceptual layout** of mission and space vehicles, weight breakdowns propulsion requirements, and new engine or cluster requirements which may be involved.

Specific calendar years will be critically assessed, together with methods to alleviate detrimental effects. This will involve a consideration of such typical possibilities as reduction of payload, increase of accepted risk, reduction of mission objectives, high earth-arrival speeds, electrical and nuclear pulse propulsion systems, increased mission duration, elliptical capture orbits, and change of mission staging method.

Bendix Soil Study

Washington—Bendix System Div. has been awarded a $27 500 contract by the National Aeronautics and Space Administration to compare the behavior of soils in earth and space environments. Purpose is to obtain additional data on soil composition and textures under temperature extremes and high vacuum on the lunar surface.

Ten month study will be carried out at Ann Arbor, Mich.

"When you've got a microwave tube problem and want technical information, you want it fast. That's why we've set up 12 field offices around the country—so that we can put a top technical man, or a whole team, in your office within 24 hours. We want to be sure you get information that's complete, accurate, and current. And this service pays off. Just the other day, as a matter of fact, another customer of ours told me he had freed one of his expediters for other work because of the efficiency of our local marketing team. It's the same kind of service we'll be giving you." *Tom Curtis (below), District Sales Manager, New York Field Area Sales Office, Springfield, New Jersey.*

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Dryden Cites Contributions of Engineers

(The following appreciation of the engineer by Dr. Hugh L. Dryden was given to the state convention of the New Jersey Society of Professional Engineers recently. Aviation Week & Space Technology is publishing it because we agree with Dr. Dryden on the role of the engineer in modern technology.—Ed.)

My own professional life has been spent on the boundary line between science and engineering. Thus I have come to appreciate the contributions of engineers who apply the material resources and the energy sources of nature to the purposes of man.

There are few groups in our nation whose work is so much taken for granted and so little understood by the public. Engineers are only too rarely associated in the press with the great accomplishments of recent times. The development of the atomic bomb, nuclear power plants, and satellites is referred to as scientific achievements in a wholly unjustified perversion of the meaning of the word science. Many writers seem to prefer the term technology to the perfectly good word, engineering. Among my daughter's textbooks I noted recently a History of Western Civilizations in which the words engineer and engineering do not appear at all.

I have often wondered why engineering of all the professions should be thus overlooked. Perhaps the characteristic feature of other professions lacking in engineering is the direct personal contact and the personal services rendered to individuals by the doctor, the lawyer, the minister, the educator. We find all around us the visible handiwork of the engineer in our bridges, highways, airplanes, ships, machines. Even in this building we recognize the electric lights overhead—the public address system, the air conditioning as produced by engineers, but whoever they are, they are anonymous. We do not recognize a professional relationship between one person and another. Engineers still have an immense task of public education. We must bring before the public the great engineers of our day as persons identified with their creative works and the contributions of these works to human welfare.

Industrial Revolution

Prior to the Industrial Revolution in the latter part of the 18th century, the word engineering referred to the work of those men who constructed weapons of war, fortifications, bridges and other works for military use. But as the Industrial Revolution progressed, there arose a new class of engineers concerned with the construction of bridges, roads, canals, ports, and so forth, not associated with military activity. Not being soldiers, they were called civil engineers. Thus civil engineering is the mother of many of the present specialized branches.

Perhaps the first specialized branch to separate was mechanical engineering, then mining. To these have been added electrical, aeronautical, metallurgical, marine, chemical, illuminating, automotive, highway, structural, agricultural, sanitary, radio, electronics, and perhaps others. The newest, not yet formally recognized, are the aerospace and astronautical engineers. The great variety and number of these prefatory adjectives have obscured the public image of engineering as a single profession.

On Oct. 4, 1957, the world entered the Space Age—the beginning of the exploration of space by sending instruments out into space to measure the universe. In actuality, the exploration of space began centuries ago when primitive man first observed the skies above and began the interpretation of what he saw. Human eyes were replaced by measuring instruments whose capabilities increased with advances in the science of physics. Astronomers by these methods have obtained an astonishing amount of knowledge about the size and extent of outer space, the number and character of celestial bodies, and details of their motion, chemical composition, and physical properties.

Mariner Data

Yet the data returned to earth in the few minutes when our Mariner 2 spacecraft flew past Venus last Dec. 14 gave us much additional knowledge of that cloud-shrouded planet, which astronomers had not been able to ascertain in the 350 years since the invention of the telescope by the methods available to them.

This 447-lb. spacecraft, which passed within 22,000 mi. of Venus, radioed in formation back to our earth stations for a total of 131 days, setting a new record for long distance tracking. At the time it executed the fly-by maneuver, Mariner 2 was some 36 million mi. distant from earth.

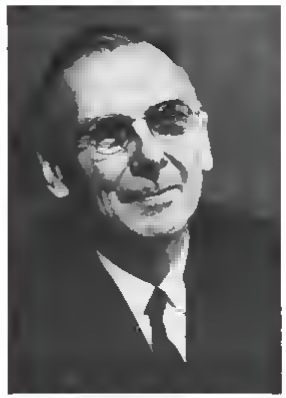
Despite the great distance involved, Mariner 2 told us that Venus has a surface temperature of some 800F, far too hot to maintain any form of life as we know it. The surface of Venus is probably dry and sandy with little or no water present. The dense clouds which surround the planet appear to be hydrocarbons in a part liquid, part-solid form which might be described as a kind of smog.

We did not lose radio contact with Mariner 2 until it was 53.9 million miles distant from earth. This is truly remarkable, since the transmitter on board has only three watts of power—about enough for the parking lights of an automobile.

The data sent back by Mariner, which has now gone into orbit around the sun, totaled about 65 million bits of information. Our scientists are still refining their interpretations of this information, and it will eventually give us still more clues to the mysteries of our nearest planetary neighbor.

Each of NASA's many flight missions is directed toward achieving one or more important parts of the national space objective. A majority will contribute to the success of the manned lunar exploration project and others will lay the foundation for future space exploration. As a consequence, the program for landing American astronauts on the moon for exploration is providing a natural focus for a large part of the effort to develop our own all competence in space, the central objective of the entire space program.

The manned space flight program is the largest single effort in which NASA is engaged. Of the $5.7 billion requested by the President for Fiscal 1964, about two-thirds, or $3.7 billion, will be expended in this area, and is related directly or indirectly to the achievement of success in Project Apollo.



Dr. Hugh L. Dryden has managed key engineering and scientific activities in the government for the past 43 years. As director of the National Advisory Committee for Aeronautics from 1947 until 1958, he played the leading role in its transition into the National Aeronautics and Space Administration, and has served as NASA deputy administrator since that agency was established Oct. 1, 1958. Dr. Dryden served in the Bureau of Standards from 1920 to 1947, where his contributions in both science and engineering fields included advances in high-speed airfoil characteristics, turbulence and boundary layer mechanics. He has been home secretary of the National Academy of Sciences since 1955.

Saturn 5 Vehicle

Saturn 5, the launch vehicle we will use to send U.S. explorers to the moon and back before 1970, is powerful enough to place the weight of 60 Mercury capsules into earth orbit and to send more than 40 tons to the vicinity of the moon.

The first test launch of Saturn 5 is planned for 1965.

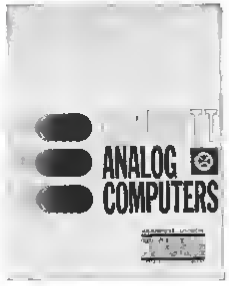
With its three stages fully fueled, Saturn 5 will weigh six million lb. It is 33 ft. in dia. and will stand 270 ft. high. The Apollo spacecraft on top will add another 90 ft., giving a total space vehicle which is approximately a two-thirds scale model of the Washington Monument in Washington, D.C.

And the vertical assembly building in which the Saturn 5 will be assembled on a new spaceport adjoining Cape Canaveral will stand 524 ft. tall. It will be, certainly the largest one-story building in the world, and will have an enclosed area equal to that of the Empire State Building.

All these activities in space itself and in the complex of supporting work that

kearfott technical information report

ANALOG COMPUTERS, CONVERTERS AND DISPLAYS



Having produced more than 17,000 analog navigation computers, we've come to the conclusion that analog computers have considerable merit. In fact, we're planning to build quite a few more.

We're not saying that digital machines are passé. There's as much need for computation in pure digital form as there is for analog. However, analog computers do have certain major advantages . . . lower cost, real time computation and elimination of elaborate converters.

When examining the requirements for navigational computers you needn't be concerned with complex programming and storage, since these considerations are inherent to analog computers.

For a further exposition on analogy, we'd be delighted to give you the booklet pictured above. Please send for it.

MINAC 5 NAV COMPUTER. We'll spell the name again—MINAC.

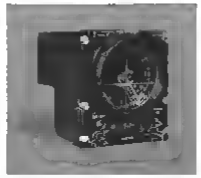
These initials stand for Miniature Airborne Navigation Computer—the best available.

For the Doppler people, there is the MINAC 5. For those who prefer inertial, we have MINAC 6.

The computer is small—occupying only ½ cubic foot. Weight is 30 pounds, including the control/indicator.

It's versatile, providing present position, wind speed and direction, distance to destination, bearing and ground track relative to true heading, true heading, ground track and ground speed. It can store two target destinations and accept alternate destinations without loss of primary data. Naturally it's accurate . . . ±0.25% of total path travelled or 1 NM/HR, whichever is greater.

A well engineered control/indicator goes with this flight tested computer.

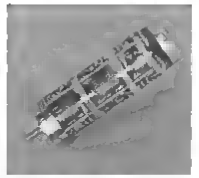


ASW COMPUTER. The AN/AYK-2 Computer with moving base capabilities further demonstrates Kearfott versatility. This computer is designed for Airborne ASW in fixed or rotary winged aircraft. The unit consists of computer and control/indicator, receiving data from any Doppler Radar set, Magnetic Compass and Air Speed Transducers. It computes N-S and E-W components of aircraft ground track and wind velocity, and of distance travelled.

The AN/AYK-2 can also incorporate a supplementary function. It receives inputs of a moving base velocity and heading, then computes and displays the bearing plus N-S, E-W data needed for the aircraft's return to its repositioned base.

Further capabilities include continuous display of present position, heading relative to take-off point and distance, and bearing to any selected one of four stored destinations.

COMPUTER/INDICATOR. Ground speed and drift angle are computed and displayed with Kearfott's T8605-22N—specifically designed for rotary wing aircraft. Input signals to the 5.5 lb, internally lighted computer/indicator are from Doppler radar, representing heading axis and lateral axis speed. We then solve for hypotenuse and cosine functions of the input voltages by a buffered resolver servo and a ground speed follow-up servo. Accuracy and sensitivity are assured from 2 to 180 knots. Doppler radar noise is damped above 10 cps. The T8605-22N is complete with two transistorized servo amplifiers, two transistorized buffer amplifiers and their individual power supplies, packaged in little more than 1/20 of a cubic ft. Environmental performance of our compact computer package meets all applicable requirements for MIL-E-5400, MIL-E-5272, MIL-E-5422 and MIL-I-6181.



A-D CONVERTERS. Proving we're not really anti-digital—and because we know there's a good market for better products—we've developed the finest Shaft-to-Digital encoders available—all in the standard size 11 diameter. These encoders are complete with external logic, and provide BCD (8-4-2-1) shaft position output with overall accuracy of ±¼ bit.

They're available in ranges from 0-999, 0-9999, 0-99999, 0-3599, 2^9, 2^{12}, and ±89.9.

The converters can be read on the run, or on demand, at speeds up to 500 RPM, and sampling rates of 50,000 counts per minute without ambiguity. With proper maintenance, exceptionally long life is standard—5×10^8 cycles at 500 RPM with an increase of 3×10^8 cycles possible.

Other characteristics include low torque—0.3 oz-in., low inertia—25 gm-cm² power ±6VDC 2 Ma per bit.

Each encoder contains "OR" gating, and is designed for serial interrogation to allow time sharing of selection logic and encoders.

Gold alloy tracks and brushes make for low noise and minimum wear.

DELSIN. Another display problem is solved with Delsin, Kearfott's solid state indicator, accepting BCD input—displaying alpha-numeric values on a seven segment electroluminescent panel.

The standard 3' indicator above contains a binary-to-decimal converter, driver, lamp encoding matrix, solid state switching matrix, lamp and associated electronics.

Delsin is also packaged in stick form, incorporating all necessary logic and switching circuitry and lamp, for individual alpha/numeric digits in a self-contained unit. Delsin sticks can be stacked side by side, developing a display of any word length. A typical 3-digit stick form display is about the size of a cigarette pack, and provides 7 ft. lamberts light output. It operates over a temperature range of −55° C to +71° C, and meets all applicable requirements for MIL-E-5400.

GENERAL PRECISION AEROSPACE
KEARFOTT DIVISION
LITTLE FALLS, NEW JERSEY

goes forward here on earth draw upon almost every branch of science and technology. In the process the needs and interests of engineers and scientists are drawing closer together and the lines of cleavage between the various disciplines are becoming less and less distinct.

To an unprecedented degree, scientists and engineers need to know the same facts although their motivations may be quite different. The scientist is traditionally interested in abstractions and theories which explain the results of past experiments and hopefully allow one to predict the outcome of other experiments not yet made.

Space Environment

The engineer is also profoundly interested in finding out as much as possible about the space environment and its hazards and other effects on men and material traveling through it. Only on the basis of accurate knowledge can he design and develop craft that will safeguard crews and their equipment on longer and longer space flights.

More than ever before, engineering has become the full and active partner of science in the exploration of this newest frontier.

Obviously then, the program offers both great challenges and unprecedented opportunities to the engineer who possesses creativity and ingenuity.

The space flight missions of our national program of space exploration fall into three general categories. The first includes those missions intended primarily to produce scientific data with respect to the space environment, the sun, earth and planets and the galaxy, using telemetry of information from unmanned vehicles. The second is composed of earth satellite missions for application to the meteorological research and weather forecasting, long distance wide band communications, navigation and similar tasks. The third relates to the travel of man himself in space, at first in near-earth orbit, later to the moon and still later to the planets and outer reaches of the solar system.

The launchings of spacecraft to carry out the desired flight missions are the most visible and spectacular aspects of the space program.

It is useful to consider the flight mission as being at the apex of the pyramid of effort which constitutes the major part of the program.

Each mission rests on specific developments in three areas.

Launch Vehicles

The first of these is the development of launch vehicles. Each mission requires a suitable launch vehicle.

The second required supporting development for each mission is that of the spacecraft itself carrying the instrumentation and other apparatus required to accomplish the desired objectives. All spacecraft require communication with the ground and hence carry radio transmitters for telemetry and, if manned, for voice communication. All require a source of internal power, i.e., batteries, solar cells, nuclear reactor and turbo-electric generators or similar equipment. Many require a working fluid and auxiliary jets or auxiliary rockets for control of attitude or spin or to modify the

Hughes OH-6A lifts helicopter technology to a new high. Faster, lighter, smaller, easier to maintain, lower cost—this is the modern answer to U.S. Army LOH needs.

HUGHES TOOL COMPANY, Aircraft Division, Culver City, California

trajectory. The development of a large and complex spacecraft requires several years.

Finally, each space flight mission must be supported by an extensive world-wide network of ground stations connected by communication lines to a central control and computation center. Equipment at these stations consists of optical, radio or radar tracking apparatus, telemetry receivers, radio transmitters to send command signals, etc. For the tracking of spacecraft at distances of millions of miles and for wide-band telemetry of high-data capacity, large steerable receiving antennas are required.

These three main supporting developments below the flight mission at the apex of our pyramid are in turn supported by a broad base of advanced technology, component development and applied research in many fields of science and engineering.

Basic Research

Finally, the space effort rests on the results of basic research in all branches of science, knowledge which is prerequisite to and contributes to a wide variety of engineering applications.

In this pyramid of scientific and engineering effort there will be found requirements for the services of almost every type of scientist and engineer to a greater or less degree. In the forefront of course, are the aerospace and astronautical engineers, but the development of the Saturn launching vehicle has also enlisted the cooperation of civil, mechanical, electrical, metallurgical, chemical, automotive, structural, radio, and electronics engineers. Much of their work relates to ground handling equipment, special automotive and barge equipment, checkout equipment, and all the other devices needed to support the design, construction, testing, launching, and data gathering.

Technical Progress

Our technical progress is normally evolutionary in nature. The radically new advances usually result from the simultaneous maturing of developments in a number of fields. Some creative engineer notices that the integration of these developments makes possible the accomplishment of a task hitherto believed impossible. Consider the development of the intercontinental ballistic missile which opened the door to space exploration. The principles of rocket propulsion were known to Sir Isaac Newton. The demonstration of the major components of liquid fuel rockets was made by Goddard over 30 years ago. A large and bold engineering development applied to rockets in World War 2 by Von Braun and his associates in Germany brought forth a practical propulsion system for 12-ton rocket vehicles. This development was essentially evolutionary in nature.

By contrast, the intercontinental ballistic missile appeared full blown from the combination of this development of large rocket engines, extrapolated six-fold in size, with newly maturing developments in structures (pressure stabilized fuel tanks, integrally reinforced skin), new welding methods, etc.), inertial guidance systems, light-weight nuclear warheads and new methods of dealing with the problem of aerodynamic heating on re-entry (new blunt aerodynamic shapes, heat sink designs, new ablating heat shields, etc.).

It is probable that there will be similar bold assemblies of developments in diverse fields to create new capabilities in space, for example in the nuclear rocket propulsion of large spacecraft. But much of the space development will continue to be evolutionary. Research and engineering development of spacecraft have enabled us to proceed from the non-lifting, uncontrolled capsule to maneuverable lifting spacecraft. Research and engineering development of materials will let us progress to the use of better metal alloys and ceramics which melt only at very high temperatures. More complex and versatile communications and computer techniques will be developed. Other areas will show like advances. In each case the goal is to obtain devices to withstand still higher speeds, temperatures, or other adverse environmental conditions, and simultaneously not only retain present performance and reliability but, if possible, improve them.

Engineers who like challenging jobs will find that space exploration demands the utmost in developments at the frontiers of knowledge.

Space Frontier

Space is thus a new frontier in many senses. I commend to your reading Ralph J. Cordiner's discussion of the new frontier in his lecture in the "Peacetime Uses of Space" series of the University of California. I will close with a few quotations from his lecture.

"At this stage, the new frontier does not look very promising to the profit-minded business man, or to the tax-minded citizen."

"Every new frontier presents the same problem of vision and risk. Leif Ericson discovered America 500 years before Columbus, but apparently the Vikings did not have the vision to see anything worthwhile on that vast, empty continent, and so history waited for another half millenium."

"When a new frontier is opened, the new territory always looks vast, empty, hostile, and unrewarding. It is always dangerous to go there, and almost impossible to live there in loneliness and peril. The technological capacities of the time are always taxed to the utmost in dealing with the new environment."

"It takes an immense effort of imagination for the citizens to see beyond these initial difficulties of opening a new frontier. No one would pretend to foresee all the economic, political, social and cultural changes that will follow in the wake of the first exploratory shots in space, any more than the people in the days of Columbus could foresee the 20th century world. But such an effort at prophetic imagination is what is required of us as citizens, so that we will not, like Leif Ericson, leave the making of the future to others."

The age of space exploration is indeed a tremendous challenge to engineers as well as to citizens. To engineers it is a challenge to make the visions come true, "to reduce design concepts to hardware with minimal cost and waste and the maximal useful results;" a challenge to continue to lead at the new frontier in contributions to the welfare of mankind.

Why so many?

We admit it.

Amphenol, more than any other connector manufacturer, accepts responsibility for confronting you with a seemingly endless selection of rack and panel connectors.

There's a good reason.

For some uses a ten contact connector the size of an Idaho potato will do just fine. In others, ten connectors must be squeezed into a space no bigger than a jelly bean. Still other applications have unique requirements that relate to environment or mating force—even the technical skill of the operator.

WHY WE DO IT

We make a lot of different rack and panel connectors because it takes a lot to satisfy the wide range of applications.

For example, the Amphenol Blue Ribbon® rack and panel connector is widely used in "blind" mating applications. Part of Blue Ribbons popularity is due to the fact that they mate with a smooth and gradual wedge-like force. Because they mate so smoothly, the "feeling" of correct alignment is unmistakable.

Another advantage of the Blue Ribbon design is the wiping action that occurs as connectors mate. Each time Blue Ribbons are mated, contact surfaces are wiped clean. Combine wiping action with high mated contact pressure, and the result is an extremely low-resistance connection.

THINKING SMALL?

As fine a connector as we know the Blue Ribbon is—it's just not right for the real tiny stuff. Thus as miniaturized electronic equipment became popular, Amphenol engineers developed the Micro Ribbon®—a rack and panel connector utilizing the ribbon contact principle but in as little as one half the space. Further development produced a circular Blue Ribbon connector which crammed 50 contacts into a diameter just under 3 inches.

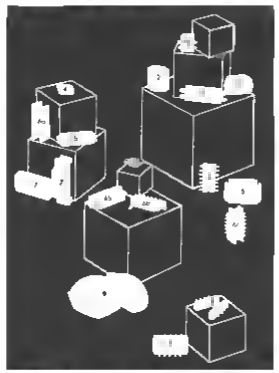
Also, there's the question of terminating rack and panel connectors. Often confined quarters or complex wired harnesses can tax the dexterity of even the most skilled worker.

To solve this problem, Amphenol engineers developed rack and panel connectors with Poke-Home® contacts. Poke-Home contacts make it possible to terminate conductors independent of the connector. Contacts are crimped, soldered, or even welded to conductors, then inserted into the connector. Besides simplifying assembly, Poke-Home contacts can be easily removed *after* assembly should circuit changes or repairs later become necessary. Needless to say, Amphenol rack and panel connectors with Poke-Home contacts (Min-Rac 17®, 93 and 94 Series, for example) are popular items with engineers who are forced to think small, spacewise.

BEATING THE ELEMENTS

There's a need for environmentally resistant rack and panel connectors, too. High performance aircraft, missiles and space craft led to the development of Amphenol 126 and 217 Series environmentally sealed rack and panel connectors. (The 217 offers the added feature of Poke-Home contacts.) Other Amphenol rack and panel connectors can accommodate coaxial connectors; many can be supplied with hermetically sealed contacts. There are rack-to-cable connectors available in every series. There are super-economy types and super-reliable types.

So when you have a rack and panel connector problem, contact an Amphenol Sales Engineer (or an authorized Amphenol Industrial Distributor). With the broadest line of rack and panels in the industry—if he can't solve it, no one can. If you prefer, write directly to Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 South 54th Avenue, Chicago 50, Illinois.



Amphenol connectors shown on the opposite page are: **1**—Min-Rac 17 with (a) crimp type contacts and (b) solder type contacts. **2**—94 Series. **3**—Micro Ribbon. **4**—126 Series Rectangular. **5**—93 Series. **6**—Blue Ribbon with (a) barrier polarization, (b) pin polarization and (c) keyed shell and barrier polarization. **7**—126 Series CNI. **8**—126 Series Hexagonal. **9**—Circular Blue Ribbon.

AMPHENOL **Connector Division** / Amphenol-Borg Electronics Corporation

Bios 2 Satellite to Orbit Primates, Plants

By Barry Miller

Los Angeles—National Aeronautics and Space Administration's Biosatellite (Bios 2) is being designed to carry a 15-lb ring-tailed monkey on low-altitude earth orbital space flights of 30 days duration to study the effects of prolonged weightlessness on the cardiovascular system, the central nervous system and on primate behavior.

The primate experiments, tentatively scheduled to be carried on the third and sixth flights in the Bios series, are one of several types of payloads under study for the Bios project. Three aerospace companies, General Electric, Northrop Space Laboratories and Lockheed Missiles & Space Co., are conducting parallel, funded eight-week preliminary design studies (AW Apr. 22, p. 37) due for completion on June 13.

Hardware Contract

After NASA's Ames Research Center evaluates the results, one or more of the three study contractors will be picked for negotiation of a spacecraft hardware contract, provided the project gets necessary funding. NASA's Fiscal 1964 budgetary requests include a $24 million request for Bios 2 satellites and launch vehicles.

Six flights are now planned, with the first shot anticipated late next year at the earliest.

Subsequent Bios 2 vehicles in the series will be launched at three-month intervals.

Purpose of the Biosatellite project is to conduct fundamental experiments in space biology that require recovery of the experimental payloads. A somewhat similar effort was undertaken in the aborted Bios 1 program (see box) but the current Bios project will be the nation's most comprehensive effort in space biology.

Particular interest will center on the effects of weightlessness on cellular processes. Whether fertilization can occur in weightlessness, whether metabolism proceeds at normal rates and whether mitosis takes place under these conditions are some of the questions for which answers are to be sought in the project.

Criticism of the Bios project was voiced recently at the Aerospace Medical Assn. meeting here by scientists who object to the selection of a two-gas environment to support Bios experiments in the belief the project should be more closely linked to the nation's manned space program.

Bios experiments will be sustained in an environment consisting of 18 to 22% oxygen, the remainder nitrogen, pressurized to sea level—14.7 psia ±10%. This is in contrast to the single gas cabin environment contemplated for support of manned space missions in the Gemini and Apollo programs (AW May 13, p. 85). Consequently, the anticipated heavy funding for the Bios project, these critics argue, will add very little to the meager knowledge about the effects of a single gas system and hence will be of little value to the space agency's immediate manned space program.

Countering this, Bios proponents cite the fundamental nature of the experiments, their broad, long-term scientific value, the fact that they are not intended to directly support immediate space flights although some Bios fallout will accrue to the benefit of manned flight.

Ames currently is screening 119 proposals for Bios experiments submitted by the scientific community, the bulk of them dealing with weightlessness and biological rhythms. Proposed experiments held to be feasible from an engineering viewpoint will be separated and referred for selection to the Biosatellite Science Subcommittee of the Space Sciences Steering Committee, a group composed of leading scientists who are responsible for selecting NASA's scientific experiments. More experiments than can reasonably be expected to be flown aboard the six spacecraft probably will be funded.

Requirements of three experimental payloads indicate expected nature of the Bios 2 project. The three are:

- **Effects of weightlessness** on a small primate (Macacus Nemestrina monkey, a more docile animal and somewhat easier to handle than the rhesus monkeys which were used in previous space shots).
- **Pinpointing synergistic** or antagonistic effects of weightlessness on the susceptibility of plant and animal specimens to radiation damage.
- **Effects of weightlessness** on biological rhythms and cellular processes of plants and small animals.

72-hr. Missions

Flights one and four in the Bios 2 series are expected to carry animal, plant and cellular specimens on 72-hr. missions in an attempt to explore synergistic or antagonistic effects of a combination of weightlessness and radiation. Typical specimens being scrutinized for this group are:

- **Chinese hamsters**—Ten hamsters housed in a 4½ in. by 1¾ in. dia. container weighing 10 lb.
- **Tulip bulbs**—Twelve bulbs occupying a 1½ in. sq. box weighing a total of 2 lb.
- **Tradescantia**—A genus of herbs, such as the spiderwort. Three specimens of Tradescantia will be housed in an 8 in. long, 2 in. dia. cylinder weighing 1 lb.
- **Neurospera Crassia**—A total of ten specimens of Neurospera Crassia, a bread mold, used in genetic studies, will be housed in a ½ in. by 1 in. dia. container weighing 2 oz.
- **Chick embryo**—A quantity of three dozen chicken embryos in a ½ in. by ¾ in. container weighing 1 lb.

Radiation Tests

Specimens will be irradiated by a radioactive source not exceeding 1 curie located at the apex of a cone in which are located the specimens to be irradiated plus a second group of experiments that are to be shielded. Cone dimensions will be 2 ft. in height, 1½ ft. in base dia. The radioactive source with shielding will weigh about 25 lb. Environment of the experiments is to be temperature controlled to 75F ±2F, with 40 to 70% relative humidity.

Dosimeter film packs will be placed among the irradiated specimens and a tissue equivalent ion chamber and a radiation spectrometer will monitor dos-

Bios Development

Biological Investigation of Space (Bios) began in April, 1961, as a follow-on to the Nuclear Emulsion Recovery Vehicle (NERV) project (AW Sept. 26, 1960, p. 26), a recoverable experiment aimed at determining the radiation profile of the inner Van Allen belt.

After the first of the six NERV vehicles built by General Electric, was a complete success, four of the remaining vehicles were modified and along with two boosters were diverted into a new program called Bios 1, an effort to study radiation and weightlessness on biological specimens and obtain more refined radiation belt data. Two Bios 1 vehicles were separately launched by Argo D-8 solid propellant vehicles in November, 1961, but both vehicles landed well beyond the reach of recovery forces.

Bios 1 payload vehicles weighed 138 lb. at liftoff. The recovery vehicles were 88 lb. at liftoff and 78 lb. at water impact. Bios 1 carried a C-band radio beacon, for tracking of the vehicle, and a de-spin system.

It is anticipated that with its NERV success, and in view of the fact that the Bios 1 failures are attributed to improper booster trajectories, not spacecraft malfunctions, General Electric will propose a scaled up version of Bios 1 in the present Bios 2 preliminary design competition.

Don't land here with any other supersonic fighter.

The Northrop F-5 is the first U S supersonic aircraft designed to operate from unpaved and unimproved runways. This capability makes it extremely effective at dispersed bases or in forward areas.

The F-5 can take off from sod fields to carry out missions as an air-to-air fighter, attack fighter/bomber, close support weapon, or reconnaissance aircraft.

It weighs only 8,100 pounds unfueled, yet the twin-jet F-5 can carry 6,200 pounds of ordnance payload and extra fuel

In clean configuration, it has a sea level rate of climb of 30,000 feet per minute, and can fly supersonic at altitudes up to 50,000 feet. In ferry configuration, maximum range is a healthy 1,650 nautical miles.

Yet with all this performance and capability, the twin-jet F-5 is an extremely practical aircraft to service and maintain.

All systems and components are accessible from ground level without special workstands or ladders. Engines are so lightweight and easy to remove they may be changed manually if necessary.

One-fourth of the fuselage area is composed of doors and panels which give rapid access to all the internal components.

These are some of the reasons why the F-5, in operational squadrons, will require considerably less man-hours of aircraft maintenance per flight hour than other supersonic fighters. **NORTHROP F-5**

Droop leading edge of A3J wing consists of 6 titanium duct units for boundary layer control

How to make a great airplane greater!

Welded Titanium Ti-5Al-2.5Sn boundary layer control saves weight, ducts air at 750° F, ups performance of A3J

North American Aviation has succeeded in upping the performance of the already great Mach 2 attack airplane, the A3J Vigilante, with an all-titanium boundary layer control system. Components of the system include complex weldments of Titanium Metals Corporation of America alloy Ti-5Al-2.5Sn, ducting air at 750F.

Imaginative NAA engineering produced two substantial dividends in improved titanium fabrication, reliable welding procedures for Ti-5Al-2.5Sn—and a novel plastic film wrapping technique that makes permanent welding chambers an expense of the past.

Even higher performance for A3J. The droop leading edge of the wing consists of six titanium assemblies which duct 750F air to the upper surface of the wing for added lift when needed. This gives the famous A3J even better carrier take-off and landing characteristics—increased range, payload, and maneuverability.

Weight-saving and strength at 750F. The 300-pound titanium system saves 300 pounds over stainless steel and other ferrous alloys that are capable of providing the necessary strength while handling gases at 750F.

All in all, more than 1,000 pounds of titanium are flying with the A3J—ribs, shroud hinings, fasteners—thereby shaving an almost equal amount of dead weight off the airframe!

The right modulus for retrofit is provided by titanium, which is right at home in an aluminum structure. This is another reason for NAA's choice of titanium. It provides the proper distribution of flexing stresses in the A3J's aluminum wing. Also important is titanium's immunity to salt spray corrosion.

To find out more about welding Ti-5Al-2.5Sn, write TMCA Technical Service Department. Remember, TMCA's exclusive concentration on titanium .. TMCA's unbroken history of research and development since the metal's earliest beginnings .. are your best assurance of successful application of light-weight, high-strength titanium.

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age received by the shielded experiments. Outputs from the spectrometer and the ion chamber will be commutated with experiment compartment total pressure, temperature, relative humidity and partial pressures of the two gases and transmitted to ground stations once per orbit. Energy required will be 600 watt-hr, with a peak power requirement of 40 w for a 2 min duration.

Flights two and five will carry experiments designed to investigate the effects of the space environment on biological rhythms and the effects of weightlessness on cellular processes in plants and animals. These will involve flight durations of 21 days.

Typical Specimens

Typical specimens considered for inclusion:

- **Ionopsidium**—A form of algae, numbering six in quantity will be placed in a 2-oz., 1¾-in.-dia. cylindrical package measuring 3 in. in length.
- **Pinto beans**—Four pinto beans located in a 4 by 4 by 6 in. container weighing 12 lb.
- **Neurospora**—Mold spores useful for studying mutations or genetic effects will be placed in a foot long cylindrical package of ¼ in. dia. Eight spores will be in the 1-lb. container.
- **Tribolium**—Two small brown beetles (Tribolium) situated in a 6 in. dia. 6 in. long cylinder weighing 6 lb.
- **Cockroaches**—Three in a 4-in. square container weighing 3 lb.
- **Syrian hamsters**—Four in a 14-ft. dia. 6 in. long cylindrical package weighing 20 lb.

The first two specimens would be photographed by time lapse photography and all but the beetles and cockroaches will be artificially lighted during flights.

Typical biorhythm data to be monitored during flights would include hamster temperature, activity and feeding, algae acidity, oxygen partial pressure and turbidity, cockroach activity and electromyograph. The data will be collected, commutated, recorded on a 100 mm. capacity tape recorder and played back at 22:1 playback/record speed ratio for transmission to ground. Energy required for these experiments will be 600 watt-hours.

Flights three and six, the first to take place some time in 1965, will carry ring-tailed monkeys on low altitude flights of 14 and 30 days duration. Electrodes will be surgically implanted in the animal's brain to obtain electroencephalograph, possibly in the aorta for obtaining cardiac information and at other points within its body for deep body temperature. Other electrodes will be sutured to the skin for electrocardiograph and respiratory information.

The entire primate experiment will consist of the monkey, a life cell couch to protect him from high acceleration forces, a life support system, instruments and 80 lb. of equipment, such as a psychometer tester, cameras, lights, excreta collectors.

The possibility exists of collecting urine in six hour samples, freezing it during the period extending through orbit re-entry and retrieval for post-mission analysis.

Real Time Data

When the satellite is in view of ground stations twelve telemetry channels will return real time data relating to respiration, eye movement, blood pressure, blood flow, electrocardiogram (ECG) and electroencephalogram (EEG).

A seven channel tape recorder will provide a post flight record of blood pressure, blood flow, respiration, ECG and EEG taken during re-entry deceleration and after impact.

While much of the biological and physiological data will be telemetered from space, the spacecraft will be designed to permit recovery of at least the experiments, on-board recorded data and the environmental control system for the experiments.

During the current studies, the three contractors are to explore recovery techniques and recommend a recovery operation and recovery site based on reliability, minimum cost and elapsed time from re-entry to delivery of payload to the desired point. Recovery by air snatch using either helicopters or fixed wing aircraft or recovery after water or land impact are all under study. Northrop's Ventura Div., which has responsibility for Mercury and Apollo recovery, is assisting the company's Space Laboratories in this phase of the NASA study.

Spacecraft Design

General outline of the spacecraft design and system considerations include the following:

- Spacecraft—Spacecraft is being designed to permit flexibility in exchange and inspection of experiments. Experiments are to be inserted as late as three hours before launch.
- Launch vehicle—Thor/Delta. Thor/Agena D and Atlas/Agena D are probably contenders as boost vehicles with final selection to be based on reliability, cost and ability to satisfy mission objectives.
- Orbit—Advantages of improved tracking and telemetry coverage obtained at high orbit altitudes are being weighed against increased recovery accuracy possible with a low altitude orbit. The need to hold maximum natural radiation dosage inside the experiment compartment to two roentgens per day and the effects of aerodynamic forces on attitude control requirements and on

DESIGNING FOR TODAY'S CHALLENGE... AND TOMORROW'S

The X-Y Mount was a new concept when Blaw-Knox designed and manufactured the first installation for NASA-Goddard a few years ago. Today it is an accepted design. Earlier, Blaw-Knox designed and fabricated the first Tropospheric Scatter Antennas capable of withstanding Arctic conditions. Before that were many other firsts in antenna design and fabrication. □ For the challenge of yesterday and today Blaw-Knox can offer unmatched experience. For the challenge of tomorrow Blaw-Knox has the skill and the pioneering instinct to develop the necessary antenna designs. Advanced Products Division, Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

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85' Blew-Knox Antenne with X-Y Mount soived problem of gimbal lock at Zenith for Goddard's satellite tracking station at College, Alaska.

orbit lifetime will influence high and low limits on orbit altitude

Launch from either Atlantic Missile Range (which does not have a Thor-Agena launch capability) or from Pacific Missile Range (which does not have a Thor-Delta launch capability) is being explored along with experimental constraints tracking station locations, payload weight etc

Pad modifications or new construction at either AMR or PMR can be recommended but is not considered too likely in view of the desire to keep costs down

The spacecraft will be interrogated once per orbit for at least three minutes to obtain spacecraft situation and experiment status reports

• **Re-entry**—A ballistic re-entry trajectory is to be followed. Re-entry decelerations are not to exceed 20g. The need to keep temperature within the experiments below 100F during and after re-entry may require jettisoning of the spacecraft heat shield after re-entry. The effects of errors in spacecraft re-entry alignment and retrorocket impulse variation on heating and deceleration during re-entry and on landing point dispersion will be weighed against the restraints imposed by experiments, landing site selection and retrieval requirements

• **Landing retrieval**—Landing area selection will be governed by considerations of tracking station location, ground-based command capability, orbit, landing dispersion, safety in jettisoning retropackage and heat shield and the retrieval method. Landing requirements are to be satisfied even if an air snatch is recommended. The maximum allowable deceleration which experiments are to undergo is 60g. An attenuating system to lessen impact may be explored

• **Stabilization and attitude control**—Active and passive stabilization techniques are being studied for keeping maximum acceleration experienced by the experiments during orbit to 10 g. Attitude control will not be necessary during orbit but is needed for re-entry to align spacecraft for retrorocket firing. Stabilization during the re-entry phase is necessary to satisfy requirements of heat protection and deceleration device deployment

Ames will coordinate integration of the biological payloads into the spacecraft.

Experiments will be prepared and checked out at Ames which is to have sole responsibility for coordinating the requirements of individual experimenters with the spacecraft contractor

Assisting Northrop Space Labs in addition to its Ventura Div., are Raytheon Co., probably in the area of spacecraft stabilization, and Space Technology Laboratories, which will provide telemetry.

NASA Wants Manual Blind Landing System

By Cecil Brownlow

Lucerne—National Aeronautics and Space Administration now believes aircraft pilots or space crewmen should play active roles in envisioned zero-zero weather landing systems primarily through manual control of their vehicles in response to inputs from electronically inspired display systems

NASA spokesman told delegates to the recent International Air Transport Assn's 15th Technical Conference here that the agency is moving away from earlier plans to provide the Apollo spacecraft with a fully automatic landing system Current thinking, he added, is to give crewmen an active role in descent and landing—partially because of the greater confidence such a system tends to inspire

He said NASA in general favors a zero-zero system such as that proposed by the Sperry Phoenix Co Designated Sperry Beacon Vision, the unit generates an artificial image of the approach and landing area on a windshield display system

The unit presents a runway outline similar to that provided by runway lights under visual conditions Altitude, range, attitude and velocity also are represented in a manner approaching a visual image

The NASA official added that a similar zero-zero landing capability will be required for supersonic transports and heavy V/STOL aircraft, even for VFR operations in the latter

In a report to the conference, Joseph G Douvillier, Jr and John V Foster, from the agency's Ames Research Center, described work carried out at Ames thus far towards evaluating the potential of such a manual system—but only in the context of STOL and supersonic transport needs

The object of the study, according to the report is to fulfill two special requirements First is to provide a display with which the pilot can land the airplane, making the same judgments, coming to the same conclusions and applying the same control techniques that he does during visual landings Second is to install the sensing and the display generating equipment on board the airplane, with the minimum possible ground-based equipment

Differing with government and airline proponents of an automatic or semi automatic landing techniques (AW May 13, p 45), the NASA officials cited these advantages for a display system through which the pilot would play an active role

- **Manual zero-zero landing system** should not require all of the equipment implied in an automatic system
- **Display allowing a pilot to land** the aircraft as he would under visual conditions requires no director or command information and, therefore, the equipment to compute such information would not be needed
- **Since fewer components** would be necessary for a fully manual system, it is reasonable to suppose that the unit would weigh less than automatic or semi-automatic systems, be less complex, cheaper and more reliable
- **Finally, and probably most important,** such a system would maintain the pilot at peak proficiency in the performance of his most critical maneuver This is in opposition to the automatic or semi automatic system which requires the pilot to perform in only the least demanding conditions

Still another advantage cited for a unit relying solely upon airborne instrumentation is the built-in capability of the user aircraft to land at smaller airports or other sites which do not have the ground installations needed for automatic systems—primarily accurate, highly reliable directional ILS

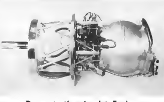
Such flexibility, the report adds, could be of great benefit to short-haul commuter airlines operating from small airports If no ground equipment were necessary, any airport with an adequate runway could become a stopping point The military too could make good use of an airborne system for operating in and out of unprepared areas

Aside from Sperry, the report mentioned similar systems under development by the Bendix Corp —Microvision —and the Microwave Remote Area Instrument Landing System (MW-RAILS) designed by the Bell Helicopter Co These systems, the report said, "provide many of the requirements Our goal is to satisfy these requirements in one display"

These requirements, as foreseen by the Ames Research officials include the following

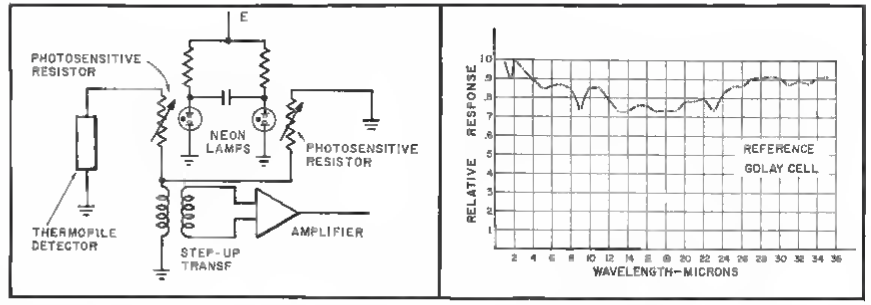
- **Pilot must be capable** of landing conventional and STOL aircraft responding to the display in the same way he responds to outside reference under VFR conditions He should be able to cope with adversities, such as gusts, crosswinds and bounces This implies that he also have the extra information upon which he can plan a wave-off should the landing deteriorate
- **Display must allow** the pilot to recognize any deterioration in the landing, at least as well as he can recognize it during visual landings
- **Pilot must be able** to use the display during VFR landings to develop confidence in the system and to gain and maintain experience and proficiency in its use
- **Display must minimize,** to zero if possible, any ambiguity or discord during transition from IFR to VFR conditions under not quite zero-zero weather conditions

Basic elements of the airborne systems planned for use in the Ames test program include a forward-looking radar for azimuth, elevation, range and range rate to the touchdown point, a radar altimeter for absolute height above the ground; inertial elements for certain aircraft motions and for smoothing the radar altimeter data, a flexible on-board digital computer to process data from the sensor equipment and generate pilot display data, and suitable pilot display devices



Demonstrotion Arc-Jet Engine

Demonstration arc jet engine, rated at 30 kw., has been delivered to Aeronautical Systems Div's Propulsion Laboratory by Giannini Scientific Co's Plasmadyne Corp Santa Ana, Calif Engine incorporates thruster, propellant storage and supply system and controls.



LOW-NOISE MODULATOR and preamplifier (left) developed to convert low microvolt-level signal from new thin film thermopile infrared detector uses two neon bulbs operating as a relaxation oscillator flip-flop to irradiate two photoconductors, alternately making one conducting while the other is nonconducting. Circuit shown uses two detectors for a spacecraft attitude stabilization application. Wideband response of new thin film thermopile detector is shown in curve (right) based on measurements made on a 20-element radial device. Thermopile infrared detector has been developed by Barnes Engineering Co., Stamford, Conn.

New Thin-Film Infrared Sensor Developed

By Philip J. Klass

New rugged infrared detector, which is sensitive over the entire spectrum without cooling, has been developed by Barnes Engineering Co., Stamford, Conn. The detector will make it possible to design spacecraft attitude stabilization systems with no moving parts.

The new thin film thermopile detector generates a small voltage when exposed to infrared radiation, in contrast to previously used thermistor bolometer type sensors which only change resistance and therefore require the use of an external bias voltage and an electromechanical chopper.

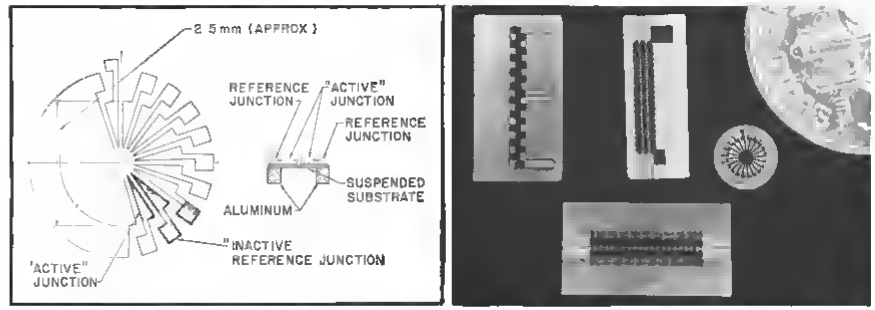
Barnes currently is applying the new type detector to several spacecraft attitude sensor or earth-presence indicator systems under contracts with Fairchild Stratos Corp., Raytheon Co. and the National Aeronautics and Space Administration's Jet Propulsion Laboratory.

The new thermopile detectors are fabricated using masking and vacuum deposition techniques similar to those employed in making thin-film microcircuits. This permits a variety of elaborate multi-element arrays to be fabricated in microminiature sizes and assures a high uniformity of the product with low reject rates. The development of the new detector and the associated circuitry required for its successful application were company-funded.

The thin-film, solid backed thermopile detector is essentially a rugged version of the vacuum thermopile previously used in laboratory instruments, but which was too fragile for many avionic applications, including spacecraft.

It provides the infrared system designer with a wider choice of sensors, usually the limiting factor in system performance (see box, p. 97).

Detectors consist of a thin sheet of Mylar, about ¼ mil thick, as a substrate,



CONSTRUCTION OF CIRCULAR thermopile infrared detector is shown (left). Closeup photo (right) shows typical detector arrays, developed by Barnes Engineering, in contrast to size of dime. Devices include 20-element edge detector, upper left in photo, thermopile with 120 active and 120 reference junctions, center, radial thermopile with 20 active and 20 reference junctions, right, and 40-element thermopile, bottom. New Barnes detector is sensitive over the entire spectrum without cooling and generates a small voltage when exposed to infrared radiation in contrast to thermistor bolometer-type sensors used previously.

with a vacuum-deposited first layer of bismuth, typically 0.0025 cm thick, followed by a layer of antimony. Other suitable materials also have been utilized.

The dissimilar metal junctions thus formed provide the familiar thermocouple action and generate a small voltage when the active junctions are at a different temperature than the reference junctions. The active junctions are coated with carbon-black or gold black to enhance their ability to convert impinging, infrared radiation into heat and change of temperature.

Detector Configurations

Barnes has produced several hundred such detectors to date, both in a circular-star configuration and in a rectangular form. In the former, the Mylar substrate with deposited layers of bismuth and antimony is mounted on an aluminum collar so that the outer ring of junctions, which serve as the reference, makes good thermal contact with the aluminum collar but is electrically isolated from it. The active junctions are those in the center of the Mylar substrate which are exposed to infrared radiation.

A similar construction is employed in the rectangular detectors with the reference junctions located along the two longitudinal edges of the substrate, which is attached to an aluminum channel so that the active junctions along the center are not in thermal contact with the heat sink.

Thin-film deposition techniques enable Barnes to fabricate 120 active junctions within an area measuring 1 x 8 mm. While the responsivity of an individual deposited junction on a solid substrate is less than that for a single junction supported in a vacuum, the ability to deposit many micro-sized junctions in a small area tends to compensate for this because the over-all response of a detector increases proportionately with the number of junctions in series.

Typical performance characteristics of the new thin-film thermopile detectors, compared with figures for typical thermistor bolometer and vacuum thermopile types, quoted by Barnes Engineering, reveal that the new detector comes close to matching the sensitivity of older type detectors and in some instances has a better time constant.

For example, the noise equivalent power (NEP), a measure of sensitivity, for a new thin-film thermopile detector containing 120 active junctions in a 1x8 mm area is 3.5×10^{-9} compared with 2×10^{-10} for a thermistor bolometer with an area of 1 x 1 mm. The new detector has a time constant of only 6 ms compared with 15 ms for the thermistor detector.

A circular configuration thin-film thermopile with 20 active elements in a 2-mm-dia size has an NEP of 7.6×10^{-10} compared to an NEP of 8.2×10^{-9} for a conventional fragile vacuum thermopile, with a time constant of 30 ms for the former and 3 ms for the latter.

While the new detector is less sensitive than its laboratory counterpart, it is far more rugged. The new cells have been subjected to MIL-STD-810 vibration tests with peak accelerations of 30g between 99 and 2,000 cps, without physical damage or deterioration in performance according to the company. The detector also has performed without degradation after being soaked in liquid nitrogen at 77K and then subjected to 100C temperatures.

Temperature Changes

Ambient temperature changes have far less effect on the new detector than on a thermistor type, providing that both reference and active junctions are exposed to the same temperature. Tests indicate that the responsivity of the new detector varies less than 10% from its 0C value over the temperature range from −60C to 80C.

Because of its relative insensitivity to

wide changes in ambient temperature and because the new detector does not require any bias voltage, it is not necessary to use an electro-mechanical chopper to distinguish between infrared radiation-produced signals and those caused by variations in ambient temperature or bias voltage. This advantage does not come without certain attendant disadvantages, according to Eric Wormser, vice president and general manager of Barnes' Defense and Space Div.

Impedance Level

For example, the impedance level of the new detector is relatively low, ranging from about 10 to 1 000 ohms. At minimum detectable radiation levels its output voltage is only a fraction of a microvolt or a few microvolts at most. To utilize a detector having these characteristics, Barnes had to develop compatible modulation and amplifier techniques.

The company has developed an all solid-state, photoconductive-type modulator for converting the extremely low-level detector output into square wave a-c for subsequent amplification to usable levels. The modulator uses two neon bulbs operating in a relaxation oscillator flip-flop circuit to illuminate alternately two cadmium selenide photoconductors (see sketch, p. 91). The modulator has a d-c noise level comparable to that of the new detectors, Wormser said. For a typical application, the circuit is designed so that the neon tubes flash on and off approximately 100 times per second, providing 100 cps modulation.

Detector Application

For the present, Barnes does not intend to sell the new thin-film infrared detector as a commercial product although it may do so at some future date. One reason for this decision is that new skills and considerable experience are required for its successful application. For example, at the microvolt signal levels involved, the use of two different materials in connecting the detector to the preamplifier, such as solder and copper, or gold wire can result in spurious voltage from unintentional thermocouple junctions if a temperature differential exists.

The two photoconductors used in the square wave modulator must be maintained at approximately the same temperature, which means that sources of heat within the amplifier must either be shielded or arranged to irradiate both photoconductors equally, according to Frank Schwarz, staff consultant and coordinator of research and development at Barnes.

The modulator circuit must be designed for extreme stability. Despite several years of work on such circuits,

Infrared Detector Limitations

Characteristics of previously available infrared detectors which have limited their use or performance in spacecraft stabilization and other applications include the following:

- Photoconductor detectors made from semiconductor materials, are far more sensitive than any other type but their sensitivity is limited to the near-visible end of the infrared spectrum (about two microns) unless cooled. To operate beyond about eight microns, where spacecraft stabilization sensors operate best, the photoconductor-type detector must be cooled to liquid helium temperature, which adds weight and complexity and poses reliability problems.
- Thermistor bolometer, which has lower sensitivity but is responsive over the entire infrared spectrum without cooling, has been widely used in spacecraft. However, it requires the use of a large biasing voltage to detect minute changes in detector resistance, about one part in 10 million, produced by infrared energy impinging on a tiny carbon flake and raising its temperature. Since a change in ambient temperature or bias voltage can produce an effect which is indistinguishable from infrared heating, it is customary to use a second thermistor flake in the detector which is connected in a bridge circuit with the active flake but not exposed to infrared radiation.

  While it is easy to match the resistance of the two flakes for good compensation at any one temperature, it is nearly impossible to get two flakes whose resistance changes identically over the wide temperature range encountered in satellite applications. For spacecraft use, it is therefore necessary to use an electro-mechanical chopper which alternately exposes the active flake to infrared radiation then blocks out the radiation. This provides a dark reference signal level and an illuminated signal level, the difference being proportional to the impinging radiation. A capacitor inserted between the thermistor detector and the preamplifier blocks signals resulting from slow ambient temperature or bias voltage changes while passing only the alternating signal produced by the chopper. But the chopper motor poses bearing-lubrication problems in the space environment in addition to adding to system weight and power consumption.
- Vacuum thermopile detector, long used in laboratory-type instruments, employs junctions of dissimilar metals with the active junction suspended in a vacuum from rather fragile supports. This type detector requires no bias voltage and generates a small signal voltage when its active junction is exposed to infrared energy. It is too fragile for use in missile, aircraft and spacecraft applications, however.

Schwarz says, the company is not fully satisfied with the results and is developing improved circuits.

Company officials fear that if the new thin-film thermopile detectors were placed on the market today, many companies would try to apply them without sufficient background and might become disillusioned. Until the applications technology is firmly in hand, Barnes plans to sell the new detectors only in systems which it has engineered itself.

Approximately two-thirds of the power consumed by conventional infrared stabilization sensors is used by the chopper motor, which can be eliminated using the new type detector. Equally important, a potential source of system failure in satellites intended for long operational life is eliminated.

FILTER CENTER

►**X-15 Measures Rocket Spectral Emission**—Air Force has developed a novel approach for measuring the spectral emission of rocket engine plume at extremely high altitude and the background radiation from the earth. The technique utilizes the X-15, presumably to obtain data for use in missile early warning satellites, such as the Midas (AW Sept. 24, p. 54). An ultraviolet scanning spectrometer, built by Barnes Engineering Co., Stamford, Conn., is installed in the tail of the X-15 so that it can view the plume of the aircraft's rocket engines during powered flight. When the engine cuts out and the X-15 is arching upward, the spectrometer views the earth's ultraviolet background radiation. The 42-lb. device measures over the 2,000- to 3,200-Angstrom range with a resolution of 2-3 Angstrom. A special logarithmic compression technique enables the Barnes device to measure radiation intensities over a 5,000:1 range with an accuracy better than 10%, according to the company.

►**Quantum Electronics Group May Form**—Questionnaire-petitions are being circulated among scientists working in the field of lasers to determine interest in forming a new Institute of Electrical and Electronics Engineers professional group on quantum electronics. Majority of those surveyed favor the formation of such a group.

►**Powerful CW Laser Reported**—A continuously operating laser which gen-

crates 9 w of power has been achieved by Air Reduction Co.'s research laboratories, using a four-level dysprosium-doped calcium fluoride crystal excited by four xenon high-pressure lamps in a cloverleaf-type cavity. The power level is 30 times that previously reported for CW lasers, the company says. It expects to apply improved versions commercially for welding light-gauge metals and chemical synthesis.

▶ **Antennas Calibrated From Stars**—Air Force Cambridge Research Laboratories are using the energy from two radio stars, Cassiopeia A and Cygnus A, as standard known signals to measure the efficiency and performance of large antenna dishes which previously were extremely difficult to evaluate. The procedure, developed by AFCRL's Space Physics Laboratory, is based on recent theoretical work by Prof. H. C. Ko of Ohio State University.

▶ **USAF Plans New Microcircuit Hardware**—Aeronautical Systems Div., Dayton, is seeking qualified sources for development of a pulse code modulation (PCM) telemetry transmitter using thin-film and semiconductor microcircuitry. Program is designated KEB-4107-64-8. ASD also is seeking qualified sources for an experimental UHF high-power microcircuit solid-state transmitter capable of delivering more than 100 w. (KEB 4335-64-6C). Also, development of techniques suitable for an extremely reliable anti-jam system using microcircuitry is designated KEB 4335-64-6A. Still another program for which qualified sources are sought calls for development of a completely solid-state telemetry transmitter and receiver for UHF and microwave frequencies "utilizing unique components and techniques for vastly reducing volume, weight and power consumption," identified KEB-4107-64-11A.

▶ **Microcircuit Activities Expand**—Airborne Instruments Laboratory and Radiation, Inc., are two of the latest avionics equipment manufacturers to set up in-house microcircuit fabrication facilities. The AIL group is emphasizing sequential process thin-film techniques, while Radiation is working with semiconductor microcircuitry. The trend is likely to accelerate as a result of the recent Bureau of Naval Weapons Avionics Div. microcircuit conference, which impressed those in attendance with the large number of avionic equipment manufacturers now applying microcircuitry to new designs.

▶ **Microcircuit AN/ARC-104 Impressive**—Of the various types of Navy avionics equipment using microcircuit construction reported or shown at the recent BuWeps conference, one of the most impressive was the AN/ARC-104 high-frequency, single-sideband transceiver being developed by Radio Corp. of America. RCA has been forced to devise a number of new design techniques to enable the ARC-104 to be built without inductors and mechanical tuning mechanisms used in conventional designs. The ARC-104 is expected to occupy about ½ cu. ft., roughly half the space of the present ARC-65 single-sideband transceiver.

▶ **BTL Reports New Gas Lasers**—Laser action has been observed in four new gases—nitrogen bromine, carbon monoxide and sulphur hexafluoride—by scientists at Bell Telephone Laboratories. The new gas lasers operate on the basis of breaking up a polyatomic molecule so that the atoms attain an excited state conducive to laser action, a principle first employed in the oxygen-argon and oxygen-neon lasers discovered in June, 1962.

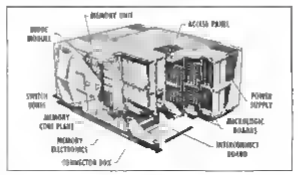
▶ **New Thin-Film Storage Element**—A three-state thin-film magnetic storage element which eliminates the need for coincident pulses for write/read-out, opening the way to greater speed and versatility, has been developed by International Business Machines Corp. New memory is made of a bi-axial magnetic material which exhibits two stable magnetic axes in contrast to previously used uni-axial material. With an intermediate magnetic state, two current pulses needed to set the element can be sequential and of shorter duration, IBM says.

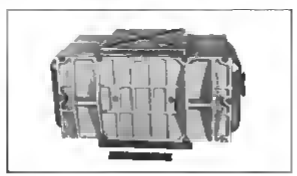
▶ **High-Resistance Thin-Film Achieved**—Thin film resistors with resistivities as high as 10,000 ohms per square, considerably higher than previously reported, have been achieved by Bell Telephone Laboratories by sputtering tantalum in a partial oxygen atmosphere, BTL reports. This permits fabrication of a thin film, 100 megohm resistor on a substrate area of only 0.02 sq. in.

▶ **Mammoth Memory Developed**—Disc file type computer memory with a capacity for 960 million characters providing access to any item of stored information in 0.02 sec., has been developed by Burroughs Corp. Nearly 6,000 remote teletype inquiry stations can be used with the new file system, the company says. It is expandable in modules of 9.6 million characters.

▶ **MIT Opens New Magnet Laboratory**—National Magnet Laboratory, with facilities capable of generating a continuous magnetic field of 250,000 gauss, has been opened by Massachusetts Institute

MAGIC—The first lightweight general purpose airborne digital computer to use molecular electronics—was introduced recently by AC. The function of the airborne computer is to handle computations and actuate vehicle controllers for guidance and control of the missile, space vehicle or aircraft. In a popular sense, the MAGIC computer serves as the brains of the total airborne guidance system.





of Technology. The $6-million facility was built under sponsorship of Air Force Office of Aerospace Research.

► **Multiple-Reflector Antenna Demonstrated**—An array of four 30-ft.-dia. parabolic antennas which are synchronized and phased to perform as a single antenna, equivalent to a 60-ft.-dia. dish, has been successfully tested at Ohio State University's Antenna Laboratory in a moon-bounce experiment. The array, built under Rome Air Development Center sponsorship, will be used for passive communication satellite tests with Echo 2 later this year.

► **EIA Microcircuit Conference**—First national conference on microcircuitry, sponsored by Electronic Industries Association in cooperation with University of Pennsylvania, will be held at Irving Auditorium, Philadelphia, Dec. 10-11. Conference on Micropower Electronics, sponsored by NATO Advisory Group for Aeronautical Research and Development, is expected to be held in June at a European site.

► **On the Corporate Checkerboard**—Radio Corp. of America's Burlington, Mass., facility has been designated as headquarters for company's Aerospace Communications & Control Div. (ACCD), which includes work carried on at RCA's Camden, N.J., plant. Dr. Harry J. Woll has been named chief engineer for ACCD. Ling-Temco-Vought, Inc., has moved its Display Systems Plant from Culver City, Calif., to Garland, Tex. The group produced Iconorama dynamic situation displays used at North American Aerospace Defense Command (Norad) headquarters.

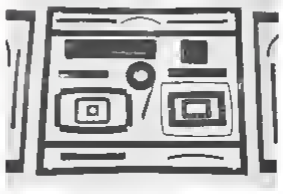
► **Signed on the Dotted Line**—Major contract awards recently announced by avionics manufacturers include:

• **Radiation, Inc.**, $3.5 million for two completely automated telemetry data processing systems, one to be used for Apollo and the other for Saturn S-2, from North American's Space and Information Systems Div.

• **Polytechnic Institute of Brooklyn** will investigate new materials, particularly organics, capable of being used in continuously operating lasers under a $71,000 contract jointly awarded by Advanced Research Projects Agency and the Office of Naval Research. Materials to be investigated include luminescent dyes and other aromatic organic luminescent materials dissolved in plastics and organic and inorganic glasses.

• **Electronic Communications, Inc.**, research division, Timonium, Md., will investigate electronic control of laser beams under a $90,510 contract from Air Force Cambridge Research Laboratories.

NEW AVIONIC PRODUCTS



• **RFI-pressure sealing products,** for preventing radio interference are fabricated from a conductive vinyl material with uniform resistivity of 3 ohms per cu cm, and operate over temperature range of —40C to 90C Material is available in variety of gaskets tubes and molded shapes Descriptive bulletin is available. Colonial Gasket Co., 302 Marlton Pike, Cherry Hill, N J

• **Miniature bulk tantalum capacitor,** containing no electrolyte, matches performance of conventional capacitors up to 10 times its size, according to manufacturer New capacitor called Hi Vol-Tan operates up to 125 v, with breakdown voltage of 200 v, and operates over temperature range of —100C to 125C Technical specifications are available General Instrument Corp, Capacitor Div – 65 Gouverneur St, Newark 4, N J

• **Silicon controlled rectifiers** for pulse-modulation applications Types MCR-729-5 through MCR-729-10, can operate at repetition rate of more than 10 000 pulses per second at up to 800 v and with repetitive pulse currents to 100 amp, according to manufacturer The devices are housed in ¼-in stud package and have a continuous current rating of 2 amp at 105C junction temperature Minimum drop-out current is 5 ma and turn-on time is quoted at 0 2 microsecond at 30-amp pulse current. Technical specifications are available. Motorola Semiconductor Products, Inc., P O Box 955, Phoenix 1, Ariz

General Dynamics Defends F-111 Design

Washington—General Dynamics officials told the Senate Permanent Investigations Subcommittee that their firm's winning F-111 tactical fighter design "represents the best and most straightforward approach to the TFX requirement and can be built for the least total program cost."

Roger Lewis, General Dynamics president, said, "I have complete confidence that we can and will deliver to the users a weapon system that will give the United States a tactical air capability second to none." He noted the firm's past performance, including the simultaneous production of five major weapon systems—Atlas missiles, nuclear submarines B-58 bombers, F-102 and F-106 fighters and Terrier and Tartar air defense missile systems. "No other company in the world can match that record," he said.

Lewis said that between 1923 and 1953, when it became part of General Dynamics, Convair produced 42 different aircraft models, while its associate in the F-111 project Grumman Aircraft Engineering Corp., has produced over 25,000 aircraft—23,500 of them carrier-based fighter or attack aircraft—since 1930.

Team Capability

"There can be no question about the capability of the General Dynamics-Grumman team, with its associated major subcontractors, to deliver to the using services an aircraft that will meet their highest requirements immediately and for the decades following," he said.

The subcommittee, headed by Sen. John McClellan (D-Ark.), is investigating award of the contract, which may eventually be worth $6.5 billion to General Dynamics, rather than Boeing.

Frank W. Davis, president of the General Dynamics' Ft. Worth Div., which is building the F-111, gave a detailed statement to the subcommittee covering the major technical points at issue in the rival General Dynamics-Grumman and Boeing designs.

• **Supersonic dash.** He said six-sevenths of the 1,700 F-111s—those for USAF—are designed for the tactical mission of dashing over the battlefield at supersonic speeds to escape ground defenses, dropping bombs and then returning to the base at subsonic speed. He said the superior dash speed of General Dynamics' F-111 design was extremely important because, among other things, it determines how far from the target the aircraft can be based. The more penetration afforded by high speed, the farther the aircraft can be based from the enemy's defended area. Taking this into account, Davis said, the General Dynamics F-111 could cover 19% more targets in Europe than the Boeing design and 14.5% more in Asia.

"This is a direct measure of wartime combat effectiveness," Davis said. "This is what you and I are paying for. Thus, the General Dynamics TFX gives you more combat effectiveness per dollar." He said General Dynamics achieved this superiority by designing its frontal area smaller than Boeing's. "This is the true significance of General Dynamics' admitted superiority in the supersonic design of the TFX. This is the guts of the whole design problem for the Air Force airplane. This advantage has been obtained only by the most careful shaping of the fuselage and wing, and by carefully positioning the engine inlets for maximum efficiency," Davis said.

• **Ferry range.** Subcommittee earlier said the Boeing F-111 ferry range was 1,100 naut. mi. longer than General Dynamics F-111 with external tanks and 450 naut. mi. longer with internal tanks (AW Mar. 25, p. 1963). Davis said the General Dynamics design "meets the range requirement comfortably," and added that the only specified USAF requirement was with internal tanks. "You can hang additional external fuel tanks on the airplane until a reasonable operational weight is reached long before the physical restraints are reached for installation of external tanks," he said. Therefore, the General Dynamics aircraft with its stronger landing gear and room for attaching hard points on the wing could actually carry enough external fuel tanks to exceed Boeing's range.

FRANK W. DAVIS

• **Bomb loads.** He said the greater capability here claimed for the Boeing design is not significant because as in the case of external fuel tanks, the General Dynamics F-111, with its structural strength, could be loaded down with whatever external bomb load was desired. "The simple fact is that either airplane can greatly exceed the bomb load requirements," Davis said. "It is also reasonable to expect that the General Dynamics airplane could be pushed to greater overload because of the greater load-carrying capability of the structure and the option exists of putting on the (stronger and interchangeable) Navy landing gear at any time that it might be desired to further increase the strength for rough field operation at extremely high gross weights."

• **Landing distance.** The Boeing F-111 was rated as being able to land in 590 ft. less distance than the General Dynamics aircraft. Davis said either design meets the requirements, adding that Boeing's superiority comes from the proposed use of thrust reversers.

• **Thrust reversers.** "The thrust reverser for the TFX must be able to stand up in service and operate very reliably even though its parts must frequently withstand the severe vibration and 3,000F temperature of afterburner operation not required in transport applications," Davis said. "In addition it must not warp or bend enough to allow even a small degradation in nozzle efficiency, for it is intimately associated with the already complex and sensitive nozzle system of the TF 30 (JTF10A-20) engine."

Dive & Wheel Brakes

General Dynamics had discussed the situation with Pratt & Whitney and the Rohr Corp., both of which build thrust reversers. Davis said, "We do not believe a satisfactory thrust reverser will be developed in time to meet the needs of early TFX airplanes," he said. Consequently, his firm will use "the tried and true" dive brake system and wheel brakes, he said. "If and when a satisfactory thrust reverser is developed," he said, "and we are anxious to aid in such development, the General Dynamics engine installation design and airplane balance will allow for its installation."

Despite these assurances, Sen. Mc-

VARIABLE SWEEP WING work on the Grumman XF10F-1 will aid in similar work on the GD-Grumman F-111, firm says.

Grumman's Variable Sweep Wing Work Cited

Washington—Grumman's experience with the complicated variable sweep wing for the XF10F-1 will help assure the success of its use on the F-111 (TFX) tactical fighter, Grumman and General Dynamics officials told the Senate Permanent Investigations Subcommittee.

Corwin H. Meyer, Grumman aircraft development director, said the XF10F-1 variable sweep wing "was based on a design considerably more complex than is necessary for the TFX." Frank W. Davis, General Dynamics Ft. Worth Div. president, said experience with the XF10F-1 wing can be applied to the F-111, making unnecessary a "special prototype program" to duplicate the experience, thus saving time and money.

Meyer was program director and project pilot for the XF10F-1, an aircraft developed in the late 1940s for the Navy. Grumman designed and built three XF10F-1s including one static test model. He said over 200 lift-offs and flights were made during the development program. In 1951, Grumman received the first production contract to procure long lead-time items for 84 aircraft, but the aircraft itself never went into production because of problems not associated with the variable sweep wing. All told, he said, the program entailed 1.6 million man-hours of engineering and 2.6 million man-hours of tooling and manufacturing. Meyer said the project established three points:

• "The variable geometry wing was structurally and operationally feasible and did provide a major state-of-the-art increase in aircraft performance.

• "Stability and control problems which would be encountered in the flight test program of a variable sweep aircraft would require unique solutions. For instance, it was learned that the lateral control or ailerons which were traditionally located on the wing tips would have to be located elsewhere on the airplane at high angles of wing sweep.

• "A variable sweep airplane should be designed with all possible concern as to the location of the horizontal tail because of the problems of pitch up associated with extreme angles of wing sweep.

• "Control surface sizing would be a significant problem with the large flight envelope provided by the much lower stall speeds and the much higher maximum speeds of the variable sweep wing."

Although Grumman proved the variable sweep wing was feasible, the Navy decided to modify carriers to incorporate the steam catapult and angled deck so they could handle many of the fixed swept wing jets already programed. But as take-off and landing speeds of carrier-based jets increased in the early 1960s, Meyer said, the variable sweep wing again looked promising. The F-111 will test the concept for large fighters.

Meyer contended that the risk of achieving the variable sweep wing on the F-111 "is greatly reduced" for the General Dynamics-Grumman design, because of the XF10F-1 experience. He cited these comparisons:

• Wing construction. "While the TFX wing rotates from a single pivot point out on the wing," Meyer said, "the XF10F-1 wing translated and rotated inside of the fuselage to provide the same aerodynamic effects. This imposed substantial structural and design problems in the routing of control, fuel and hydraulic systems through these multiple moving sections.

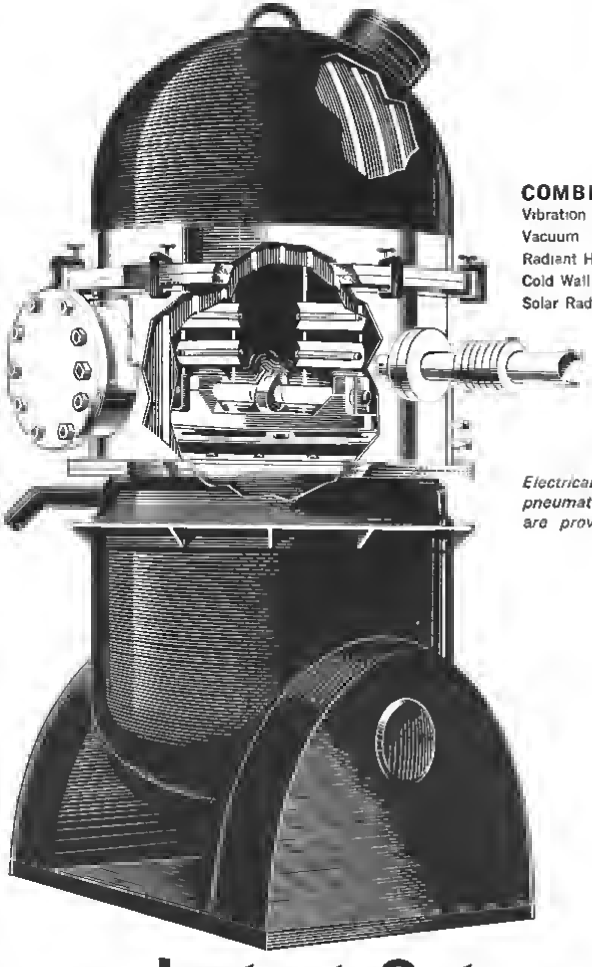
"In addition to the control, fuel, and hydraulic systems capable of operating while the wing was in motion, the wing sweep joint was designed with bomb racks that pivoted on the wing to keep the bombs parallel to the fuselage as the wing moved; integral bladder type fuel tanks; an 80% span Fowler flap; and a unique wing motion closure fairing mechanism in the wing-fuselage juncture designed to keep this area airtight while the wing was in motion. All of these systems presented design and manufacturing problems similar to those now being solved in the TFX design.

"The airplane and wing structure were designed for a 7.5g flight envelope with the wing at any position. Fatigue testing of the wing sweep elements was intensive. The wing sweep joint was designed for carrier operations with special emphasis on dynamic magnification which can occur during catapult takeoffs and arrested landings aboard carriers both with and without external stores on the wings. The wing joint structure consisted of four aluminum forgings which were the largest high strength forgings that had ever been made in the aircraft industry at that time," he said.

• Fuel system. Meyer said other unique features in the XF10F included a fuel system that controlled the airplane center of gravity during flight; a self-contained starting system; a sophisticated air-to-air weapon fire control system with a 24-in. radar antenna; and a wing fold system as well as the wing sweep system.

This folding and locking arrangement was later incorporated in another production airplane, he said.

Under subcommittee questioning, Clinton Towl, Grumman president, said his company is not in charge of the variable sweep wing design but had sent people to Ft. Worth to work with General Dynamics personnel in all areas of design.



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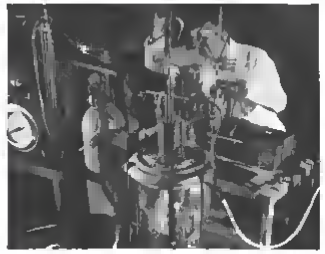

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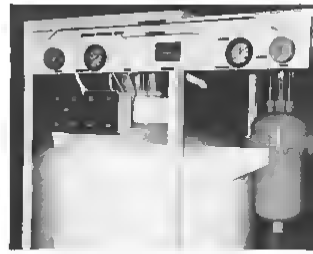
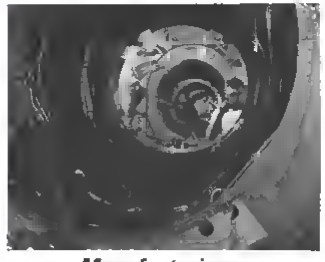


Auxiliary Power . . .

GSE . . .



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Clellan expressed fears that putting on the extra weight when the airframe was not designed for it originally, as in the case of Boeing's F-111, might reduce performance

Sen McClellan According to the Pratt & Whitney folks, it [a thrust reverser] adds about 500 lb per engine, about 500 lb per reverser, and it would be about 1,000 lb., or 500 lb on the tail end of each engine on the plane, with the two engines Would that much weight make any difference with respect to the balancing of your plane?

Davis. It would not create an insurmountable balance problem at all Actually, we would look toward the development of a thrust reverser which might be lighter than that If thrust reversers were developed and installed in the airplane, some other weight in the airplane would be deleted which would partially offset the change in the center of gravity

"Now, fortunately in the TFX, by virtue of the fact that it has a variable sweep wing, it is possible to accommodate changes in balance very easily by setting the stops to which the wing sweeps in a little bit different position, and 1 or 2 deg. difference in sweep will handle any practical amount of weight which might be added by the afterburner, or by the thrust reverser

Sen McClellan That weight on the end of the engines would tend therefore to restrict the flow or motion and swing or sweep of the wings

Davis Not to a degree which would be detrimental to any significant amount

Sen. McClellan. You don't think that it would affect the plane?

Davis. It will affect the stalling speed, I believe less than 1 kt.

Sen. McClellan. It seemed to me in the course of testimony that we have heard, that the Air Force and maybe the Navy . . . they did attach some real consideration or value to the thrust reversers, believing, I assume, that they would actually make a contribution to the operation of the plane in certain aspects of the operation

Davis. I would not suggest that provided a satisfactory thrust reverser is developed, that this would not be a good thing for an airplane . . .

Sen McClellan You said you don't think that adding 1,000 lb of weight would change the operational effect of your plane, if you put them on there, as what another witness indicated You said that you did not think it would change the operational characteristics.

Davis I said it would not change its ability to operate from a balance stand point, the carrying of additional weights does entail some operational disadvantage, and that is fairly small The big danger on thrust reverser primarily is associated with the possible effect on nozzle efficiency I indicated in my testimony that if there were enough warpage or leakage in that mechanism to degrade that efficiency by as much as 3%, it could degrade the amount of dash capability you had in the airplane by as much as 25%, so it is quite sensitive Therefore that is one of the reasons we suggest that you continue to have the dive brakes available in case that development hits some snags

Sen. McClellan. But you can't have both on the plane, can you?

Davis. As a matter of fact, you could.

Sen McClellan It might be advisable to do that Is that what you have in mind when you say that you are retaining the dive brakes?

Davis It is not quite that simple You can have both of them on the airplane physically. Now, there may be some reason for having the thrust reverser work for reducing landing roll only, and not to be used as a dive brake in the air, and it could be built lighter if that were the only requirement If that is the case, you would have a thrust reverser for ground stopping but would

still have the dive brakes for air braking.

Now, if on the other hand, it works out in the program that you can use the thrust reverser for braking in the air satisfactorily, then it could be used for that, and you could dispense with the dive brakes. So you have several options if you proceed with both developments."

• **Reaction time.** Davis challenged the claim that the Boeing F-111 would be ready for take-off in half the time of the General Dynamics F-111 because of the faster warm-up of the electronic equipment. For one thing, he said, the estimate used did not allow time for the crew to get from its ready shack into the aircraft.

• **Navy loiter time** far from the ship. Boeing's F-111 could loiter 5¼ times as long as General Dynamics', according to the USAF evaluation. Davis said this is misleading because all that needs to be done to equalize the aircraft is to add fuel to the large wing tank of the General Dynamics aircraft. However, he conceded that the weight of the fuel would increase wind over deck requirements.

• **Intercept mission radius.** Boeing F-111, on basis of its own data, showed advantage of 177 naut mi. "This appears to be a case of unjustified optimism," Davis said, adding that General Dynamics' supersonic superiority would extend to the intercept mission.

• **Inlet location.** Davis said that although the Boeing inlet, by being on top of the fuselage, would minimize foreign object damage, the lower inlet in the General Dynamics design gives "positive assurance that erratic or distorted air flow to the engine" will not adversely affect flight. He said the lower inlet is more efficient, simplifies ground inspection of the duct and engine compressor face and facilitates engine removal. He said scale model tests have shown the General Dynamics inlet is adequately guarded against foreign object damage.

• **Wheel design.** Previous testimony favored the Boeing design's dual wheels, partly because they would be easier to change. Davis said handling slings will have to be used in any case. He added that General Dynamics' larger single wheel, with its lower pressure and larger rolling surface, gives it "an obvious advantage in rolling over rough terrain." He said the Navy prefers the single wheel landing gear.

• **Optical sight.** Boeing's air-to-ground

Dornier 32 Helicopter Makes First Flight

Prototype Dornier 32 one-man, turbine-powered helicopter is undergoing its first flight tests. Designed primarily as a military machine, the helicopter is powered by a 90 hp engine developed by BMW Triebwerkbau of Munich. Engine is designated the BMW 6012. Directional control for the two-bladed helicopter is maintained by the exhaust blast over the vertical tail which is positioned by the rudder pedals. Maximum speed is about 75 mph and ceiling is approximately 20,000 ft.

fire control system calls for giving the pilot a sighting device that provides such information as the slant range, so he does not have to glance away from the target and onto the instrument panel.

Davis said his firm chose an off-the-shelf sight to minimize new developments in the subsystems of the aircraft but could make the change if desired.

• **Airplane weight.** USAF evaluated the General Dynamics Navy F-111 as 2,208 lb. heavier than Boeing's. Davis said weight difference would not be significant if Boeing installed the same fuel capacity.

• **Growth capability.** USAF-Navy evaluators felt Boeing held the edge here, but Davis contended that "growth in the basic Tactical Air Command mission will come easier to the General Dynamics airplane because of its better supersonic design." He said General Dynamics' F-111 ferry range and load-carrying capacity for the USAF version "is ensured by the option of using the Navy wing tips and the Navy landing gear."

Davis said the General Dynamics-Grumman design would be cheaper than Boeing's because of less expensive materials, a smaller total number of parts, fewer uncommon parts, simpler engine installation, conventional speed brakes, less structural testing, fewer drawings, fewer instructions, fewer similar parts which look alike but are not, superior supersonic aircraft and carrier-based aircraft experience, specific variable sweep wing experience and a better rating in the fourth USAF-Navy evaluation in the areas of production management and cost.

• **Titanium.** Air Force Secretary Eugene M. Zuckert in his Nov. 21 memorandum explaining why General Dynamics-Grumman should be awarded the F-111 contract objected to the use of titanium in the Boeing design (AW May 13, p. 27).

This was Davis' rationale for not using titanium in the General Dynamics F-111 design:

"General Dynamics has used titanium in many applications over the years; it was considered seriously for several places on the TFX. Titanium is, however, at least several times as expensive as steel and aluminum. Its properties are not as well known in the thicker gages which would be required to utilize it extensively in the heavier parts of the structure such as the wing carry-through and wing box.

"Specifically, the data available on fatigue properties shows more scatter than for steel, i.e., there is more difference in quality between the worst piece and the best piece. To design conservatively for long life, it is necessary to add enough material to account for the poorest quality piece you might expect. This would cancel part of the weight saving otherwise possible.

"Also, it was found that the size of titanium plate available was smaller than aluminum so that an additional splice would be required in the wing structure. This ate up a little more of the potential weight advantage. The increased cost for the titanium applications we studied was about $115,000 per airplane. With these factors in mind, it seems to General Dynamics that steel and aluminum offers the better alternative for most applications on the TFX."

• **Experience.** Davis said General Dynamics has the most experience in the industry with supersonic aircraft, while Grumman aircraft have made more than one-half the carrier landings and take-offs in the history of the Navy. He said with Grumman's experience with the XF10F-1 variable sweep wing jet fighter (see p. 105), "the General Dynamics-Grumman team had under its belt 4,330 hr. of wind tunnel testing and full scale design and construction experience on the XF10F-1 and 4,758 hr. of wind tunnel testing on the TFX when the proposal was submitted."

• **Commonality.** Both civilian and military witnesses in previous testimony contradicted claims by Defense Secretary Robert S. McNamara that the Boeing proposal was in effect two aircraft while the General Dynamics-Grumman design called for more identical parts and thus promised to save $1 billion through commonality.

Davis supported McNamara's finding this way:

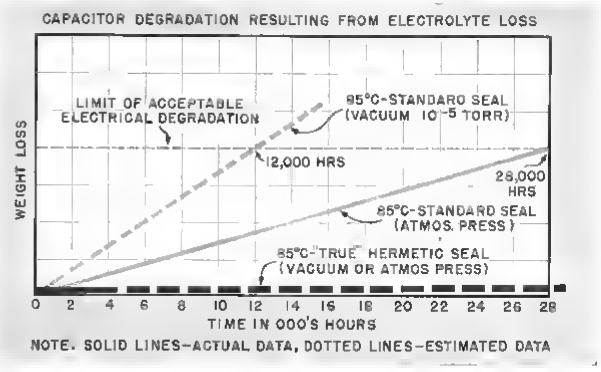
"General Dynamics commonality approach achieved one aircraft with the minimum divergency requested. The fuselage, wing and tail of both versions of the General Dynamics TFX are structurally the same. The Navy wing tips are simply bolted on. The fourth evaluation report found that General Dynamics proposed an airframe design that has a very high degree of identical structure for the Navy and the Air Force versions.

"On the other hand, the report estimated that in the two Boeing versions less than half of the structural components of the fuselage, wing and tail were the same. The Evaluation Group concluded that Boeing, in effect, proposed two different airplanes structurally.

"General Dynamics' greater commonality was not the result of a sacrifice of performance in pursuit of a commonality goal as such. Rather, it came as a bonus from a better idea on how to satisfy and reconcile the differing performance and structural strength requirements of the two services. Dr. [Harold] Brown [director of defense research and engineering] quoted a

Accent on VALUE

New hermetic seal... new capacitor life



Now, to the inherent advantages of foil tantalum capacitors, General Electric adds a true hermetic seal. It employs a special glass which is bonded to tantalum oxide by a recently perfected process.

As shown above, this new seal increases the life of foil capacitors by virtually eliminating electrolyte loss. Combined with the high-voltage, high-microfarad, and self-healing characteristics of foil capacitors, this *added* life makes G-E foil Tantalytic* units extremely well suited for use in missiles, satellites and other electronic systems where high reliability is required.

Outstanding advantage of the glass seal over a seal of organic material is that glass will not out-gas when exposed to vacuum or radiation. Glass is more stable to the chemical action of electrolyte, too. Both features reduce the possibility of contaminating vapors entering surrounding equipments, and improve capacitor reliability.

In developing the hermetic seal, General Electric has had the support of North American Aviation's Autonetics Division as a part of the program to develop High Reliability capacitors for the Air Force Minuteman. More recently, U.S. Army Electronics R&D Laboratory awarded G.E. a contract to support development of a hermetic seal for standard foil capacitors.

Ratings of the new hermetically sealed capacitors are 85 C and 125 C, 15 to 150 volts, and 75 to 610 microfarads. They come in 3 case sizes, of polar and non-polar construction.

Ask your General Electric Sales Engineer about the units now available from stock for prototype work. He'll be happy to assist you with application, too. For more information, write for Bulletin GEA-7614, to Section 430-16, General Electric Co., Schenectady, N. Y. *Electronic Specialty Capacitor Product Section, Irmo, S. C.*

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Progress Is Our Most Important Product

GENERAL ELECTRIC

Navy evaluation briefing as describing our bolt-on wing tips as an elegant and preferred solution' The bolt-on tips, the interchangeable landing gear, the common wing fuel tank and the strength for the same top speed for the Navy and Air Force have been shown to provide performance bonuses when advantage is taken of them . . .

"Several of the witnesses have attempted to disregard commonality as a cost saving feature with a simple reference to Boeing's lower quote Also some confusing testimony has been given about similar parts being as cheap as identical parts because the same assembly fixtures may accommodate parts having certain types of differences But assembly tooling is only part of the story Each part must be fabricated as a separate unit On the average about 2 5 fabrication tools are required per part

Tooling Cost

"The use of techniques such as numerically controlled machines in the manufacture of parts for modern airplanes has been cited and is recognized as offering substantial economies by reducing fabrication tooling cost For the last five years General Dynamics has used tape controlled machines in the fabrication of production parts Many of our suppliers are using these machines and are realizing substantial savings

"The actual forming, milling, guiding, drilling, and finishing of a part is not the major part of the total task required to incorporate it as an item in the delivered product The major cost is generated by the need for designing, drawing, releasing, getting material, testing transporting, listing, stocking, analyzing, segregating, inspecting, identifying, and installing each part as a separate item by part number

Non-Identical Parts

"No matter how small the difference is between two non-identical parts, each of the actions I have mentioned must be accomplished distinctly for each part number Of the total parts in the airplane less than 5% will be made on a numerically controlled mill

"It is well known in industry that the design, development, test production and support costs for a number of identical weapon systems are less than such costs would be for a mixture of two different weapon systems The higher the degree of identity the more the savings

'The logistic support people are aware of the savings obtained by reducing the number of different stock numbers required to be carried in the system, and the dangers present in having similar parts which look alike but have different strengths or other characteristics which might inadvertently get installed on an airplane with catastrophic results This is a serious problem in peacetime with elaborate controls In wartime it can become a monumental problem"

PRODUCTION BRIEFING

Thiokol Chemical Corp. has been awarded a $1 4 million contract from the National Aeronautics and Space Administration for investigation of flight in planetary atmospheres Contract calls for design, fabrication, testing and delivery of a hypervelocity wind tunnel capable of developing a 50,000 fps airstream Device will be built at Thiokol's Pocatello Ida , facility for installation at NASA's Ames Research Center, Moffett Field, Calif

Chrysler Corp has an additional $1 2 million contract from National Aeronautics and Space Administration's Marshall Space Flight Center for modification of Saturn production facilities at the Michoud Operations Plant at New Orleans, La The award brings total Chrysler modifications contracts to more than $5 million

Raytheon Co. of Lexington Mass., has received r $1 5 million contract for continued production of support components for Army's NATO Hawk program Work will be performed at the Andover, Mass plant

General Dynamics/Pomona Div, has a $5 4 million Army contract for continued development of the Redeye surface-to-air guided missile

Hughes Aircraft Co, Culver City Calif , has a $2 8-million contract from anti tank and aircraft weapon commodity manager at Army Missile Command for R&D work on a new missile system for infantrymen New system known as TOW (tube launched optically tracked wire guided missile) will be used against heavily armored tanks and similar targets As envisioned, TOW will be carried by a light vehicle or transported by infantrymen

American Machine & Foundry Co., Advanced Products Group, has been awarded a $400,000 development contract from Urbahn-Roberts Sculve-Moran, architects and engineers, for work platforms, door machinery, and vehicle handling systems for the Saturn Vertical Assembly Building at Cape Canaveral

Intercontinental Mfg Co, of G[illegible]land, Tex , has a $2 2 million Army contract for production of Pershing missile mortar cases

FMC Corp , Ordnance Div., San Jose Calif has received a $7 5 million contract for development and manufacture of Minuteman ICBM suspension and alignment systems Components will support the missile in its underground silo and aid in proper alignment as well as absorb shock from above ground explosions

Hughes Aircraft Co, Culver City, Calif has been awarded $3 9- and $7 5 million supplemental contracts for production of Falcon missiles and related equipment Contract was awarded by Aeronautical Systems Div Wright Patterson AFB Work will be done in Tucson, Ariz

Sperry Rand Corp. has been awarded a $1 2 million U S Army contract for engineering services on the Sergeant missile

Eclipse-Pioneer Div of Bendix Corp has a $990,000 contract for air data computer systems for the F-111 (TFX) fighter Computer will convert information on eight physical properties of air including pressure altitude, tempera[illegible] and Mach number and channel it to [illegible] systems and related equipment. Computer will have a growth potential of 10 additional outputs if needed Award was from General Dynamics/Ft Worth

Moog Servocontrols, Inc., has received a $372,000 contract from National Aeronautics and Space Administration for servoactuators to steer the booster stage of the Saturn 5 Apollo moon rocket

Lockheed-California Co., Burbank, will furnish NASA's Flight Research Center Edwards AFB, with three F-104 aircraft to be modified as testbeds for future projects, under a $2 3-million contract

Sikorsky Aircraft Div. of United Aircraft Stratford Conn , has a $5 million Navy Bureau of Weapons supplemental contract for electronics and electrical equipment for West German H-34 Seahorse helicopters

AiResearch Mfg. Div. of Garrett Corp. has received a $1-million contract for primary components designed to inflate a Gemini paraglider Award was made by McDonnell Aircraft Co. prime Gemini contractor to NASA's Manned Spacecraft Center Houston, Tex

Senate Group Says Cuban Data Unreliable

By Katherine Johnsen

Washington—U.S. is without reliable information on the number of Russian military troops in Cuba or on the controversial issue of whether Russian strategic missiles are emplaced on the island, according to a report by the Senate Preparedness Investigating Subcommittee.

The 34-page interim report by the subcommittee, headed by Sen. John Stennis (D.-Miss.), culminated six months of hearings and study.

The subcommittee's investigation is continuing.

Formidable Defense

The report stated that without doubt, Cuba's present formidable defensive system, which has withered any spirit for internal rebellion and elevated any U.S. invasion to a major military operation, is completely under Russian control.

Presenting the subcommittee report to the Senate, Stennis said: "They are admittedly capable of suppressing any internal rebellion or revolt mounted without external support. It is clear that an invasion from without to have a fair chance of success, would require large forces, extensive seaborne landing efforts, and adequate air cover. These Soviet soldiers there particularly the hard, armored units, could control Castro, too."

Current U.S. intelligence on Cuba is based mainly on high-level photographic flights by Lockheed U-2s.

These photographic flights are continuing "on a regular basis," according to the subcommittee.

The Russians have tolerated these flights, with the one notable exception of the U-2 shot down by a Russian SA-2 air defense missile on Oct. 27—five days after President Kennedy's crisis speech to the nation announcing a blockade of the island.

The pilot, USAF Maj. Rudolph Anderson, was killed.

No Interference

"Since the U-2 was shot down on Oct. 27 there has been no further attempt to interfere with our aerial reconnaissance," the report said. "The reason for this one incident amidst a pattern of acquiescence in the over-flights remains a matter for speculation."

In addition to U-2 overflights, merchant ships arriving and departing Cuba are being kept under close surveillance both by aircraft and naval surface ships, and also by peripheral reconnaissance and photographic aircraft.

On the matter of strategic weapons in Cuba, the Senate subcommittee observed:

"To a man, the intelligence chiefs stated that it is their opinion that all strategic missiles and bombers have been removed from Cuba. However, they readily admit that, in terms of absolutes, it is quite possible that offensive weapons remain on the island concealed in caves or otherwise.

"There are literally thousands of caves and underground caverns in the island of Cuba and many of these are suitable for the storage and concealment of strategic missiles and other offensive weapons. Military-connected activities have been noted that reference to a number of them, but it is the view of the intelligence analysts that the military usage of the caves is for the storage of those weapons which we know are now in Cuba and not for the storage of offensive weapon systems. Admittedly, however, this view is based to a substantial degree on the negative proposition that there is no hard evidence confirming the presence of strategic missiles in Cuba at this time," the subcommittee said.

'Criticality' Cited

Even though the intelligence community believes that all have been withdrawn, it is of the greatest urgency to determine whether or not strategic missiles are now concealed in Cuba. The criticality of this is illustrated by the fact that, assuming maximum readiness at pre-selected sites, with all equipment pre-located, the Soviet mobile medium-range, 1,100-mi., missiles could

Crusader Photographed During Night Recon Flight

Chance Vought RF-8A (F8U-1P) photo aircraft is photographed at six different positions in a time exposure which was made while the aircraft made a photo pass over a simulated enemy base. Planes are designed to provide light for a forward-facing camera mounted on the Crusader. Aircraft is flying at less than 800 ft. while making the photographic run. Technique was developed by Navy Photo Squadron 62, based at Cecil Field, Fla., Naval Air Station.

be made operational in a matter of hours."

The official estimate in the intelligence community—Central Intelligence Agency and the intelligence branches of the military services—is that there are now 17,500 Russian troops in Cuba. This figure, as is the estimate on strategic forces in Cuba, is arbitrary and without any basis in hard-core fact, the subcommittee noted.

The unreliability of U.S. estimates on Russian military manpower in Cuba, a difficult figure to establish through aerial reconnaissance, was demonstrated by the subcommittee as follows:

On Oct. 22, when President Kennedy delivered his crisis speech, the official estimate of the intelligence community was that there were 8,000 to 10,000 Soviets on the island. The official estimate now is that at that point in October, at the height of the build-up, there were "at least 22,000 Soviet personnel" on the island.

This erroneous underestimate, the subcommittee implied, was the reason that the President did not include a demand for the removal of Russian troops, along with his demand for a removal of Russian strategic weapons, in his address to the nation.

It was not until Oct. 25—three days after the President's speech, that the intelligence community identified the presence of organized Russian ground combat forces in Cuba. On this date, pictures obtained by low-level photography resulted in the conclusion that "there were, in fact, four organized, mobile, and powerful armored Soviet units in Cuba."

As late as Oct. 29, the subcommittee noted, Defense Dept. published a brochure stating that there were about 5,000 Soviet "personnel" in Cuba.

The estimate of exile sources, the subcommittee noted, is that there are now over 40,000 Russian troops on the island.

The intelligence information that culminated in the President's Oct. 22 address was presented by the subcommittee.

These were the main points:

• Before mid-1962, U-2 flights over Cuba by CIA were increased in frequency, starting early in 1962. Reconnaissance and photographic flights were also being flown on a regular basis over international waters by the military services—but not over Cuba itself.

By 1962, it was estimated by U.S. intelligence that there were about 500 Soviet bloc advisory personnel in Cuba and that the Cuban air force had been reinforced by about 40 MiG-15s, -17s and -19s and strengthened by the training of Cubans in Soviet bloc countries.

Although more concerned, the U.S. intelligence community, until mid-July, 1962, still evaluated the Cuban situa-

tion as primarily a defensive build-up • July-Oct. 22, 1962. Starting in late July, there was a marked increase in Soviet ship arrivals in Cuba. The intelligence community also ascertained that the Soviet ships were unloaded at night under rigid security with all non-Soviet personnel excluded from the dock areas.

On Aug. 29, U-2 overflights detected two SA-2 (SAM) sites at suspect locations, plus sites at six other locations. During the following week, two more SAM sites were discovered (AW Oct. 1, p. 20).

The SAM air defense missile, comparable to the Nike-Hercules, has an altitude of up to 80,000 ft. and a slant range of about 25 mi.

The presence of the MiG-21 supersonic jet fighter in Cuba was confirmed by a picture obtained Sept. 5. Confirmation of pictures showing crates containing Il-28 Beagle bombers on ships that were bound for Cuba was made Oct. 9.

Finally, on Oct. 14, a U-2 overflight by Strategic Air Command obtained hard photographic evidence of a medium-range ballistic missile complex at San Cristobal.

Between Oct. 14 and Oct. 22 SAC flew 17 high-altitude sorties. Low-altitude overflights were not initiated until Oct. 23, the day following the President's message.

Six medium-range ballistic missile sites, all with full operational capability, had been located by Oct. 28, when dismantling commenced. Three intermediate-range (2,200 mi.) ballistic missile sites, which would have become operational by about Dec. 15, had also been located.

At the time the USSR announced withdrawal of 42 missiles from Cuba, U.S. intelligence had estimated less than that number on the island. "It could not be established, therefore, how many ballistic missiles were, in fact, introduced into Cuba or specifically how many the Soviets planned to introduce," the subcommittee stated.

The subcommittee discounted reports of a jurisdictional dispute between CIA and SAC on U-2 overflights which resulted in an alleged "photographic gap" from Sept. 5 to Oct. 14.

Between Sept. 5 and Oct. 7, CIA made five U-2 overflights. Additional flights scheduled for this period were canceled because of weather. The Oct. 14 flight was transferred to SAC because of the possibility of attack by SAMs. "This decision was entirely reasonable and proper," the subcommittee said.

Allegations that there was a deadlock between CIA and SAC regarding overflights and that this resulted in delay in locating medium-range ballistic missile sites in Cuba "have been found to be

without merit," the subcommittee commented. "There is no evidence whatsoever to suggest that any conflict between CIA and SAC existed or that there was any delay in photograph coverage of the island because of the fact that the U-2 program was being operated by CIA prior to Oct. 14."

Subcommittee Concern

It is a fact, of course, that the first U-2 flight flown by SAC was the one which resulted in obtaining a photograph of the medium-range ballistic missile site. This, without explanation, originally gave the subcommittee some concern.

"However," the report continued, "after inquiring closely into the situation we are convinced that there is no significance to it and that it was just a matter of timing and coincidence."

The subcommittee made these observations on Cuba's present military power:

- **Native Cuban forces** are organized "only at reinforced battalion level" and are equipped with modern rifles, machine guns, light and heavy mortars, and field artillery. These forces also have available tanks, self-propelled artillery, armored personnel carriers, and light anti-aircraft guns suitable for use against low-flying aircraft. The subcommittee said that it is not known whether these crew-operated types of weapons are in Cuban hands.
- **The Soviet organization** controls 24 surface-to-air missile (SAM) sites of six launchers each "in a tight-knit perimeter air defense of the entire island," the report said.

The subcommittee estimated that it would take over a year of intensive training and technical schooling for native Cuban troops to replace Soviets in the SAM system.

- **Soviet naval crews** man four cruise missile sites for coastal defense, with missiles of 30 to 40 mi. ranges. The subcommittee noted that there are at least 150 of these missiles in Cuba, far more than could logically be associated with the known sites. "It may be speculated that the launchers for these missiles may have been in some of the bloc shipping turned back by the October quarantine and failed to reach Cuba," it commented.
- **Soviet naval** contingent also operates 12 KOMAR type high speed patrol craft for coastal defenses. Each patrol craft is equipped with two 10- to 15-mi.-range missiles.
- **Soviet army element** in Cuba is armed "with almost all of the weapons found in large Soviet troop formations." These weapons include very large and substantial numbers of heavy tanks and medium tanks, self-propelled assault guns, anti-aircraft guns, truck-mounted multiple launchers for rockets, radio and engineer equipment.

Soviet Equipment

Two notable types of equipment with Soviet ground forces in Cuba, the subcommittee pointed out, are Snapper, a wire-guided anti-tank missile, and Frog, a 25-mi.-range rocket which can be equipped with a nuclear warhead.

- **Soviet air units** have an estimated 42 MiG-21 supersonic jet fighters. "They are probably equipped with air-to-air missiles," the subcommittee said. "Associated with them is a net of radars and radios necessary for their control and the integration of the entire air defense system, SAMs and fighters."

Nike-Hercules Workshop Is Air Supported

Maintenance shelter for Nike-Hercules missiles is inflated to 3-lb. psi by a motor-driven blower which is kept in continuous operation to maintain pressure. The 72-ft. long structure is joined in sections. It is 45 ft. wide and 27 ft. high. Approximately 1,800 yards of nylon waterproofed by a hypalon coating are required in the double wall construction. The shelter is designed for ease of transportation and has provision for internal heating for arctic use.

DOD Official Calls for Controlled, Short Program Definition Effort

Washington—Expanding use of fixed-price incentive contracts and program definition phase studies will have as much impact on the defense industry as the technological shift from aircraft to missiles in the late 1950s, a Defense Dept official predicted here recently.

Dr James H Gardner, deputy director of defense research and engineering, said the two new management techniques are closely inter-related because both the government and the contractor must have sufficient understanding of the problems involved in developing a new weapon to permit a realistic incentive contract to be prepared. Gardner, who is scheduled to return to industry in a few weeks, made his remarks in the keynote address to the 1963 Electronic Components Conference here.

Government Needs

"We in the government must have a good understanding of the relative value to us of the various elements of performance, of cost and of the time required to complete the work," Gardner said. "These inter-relationships, which have come to be called trade-offs, must be reduced to numerical form. We must be able to tell something about the relative value to us of a 15% reduction in the circular error probability of a missile versus a 30% increase in the cost or time of development. This kind of understanding is important in making decisions to initiate programs and it is essential to the design of incentive formulas," Gardner said.

Program definition and incentive contracts are being used for applied engineering and major system developments which total about $3 5 billion in Fiscal 1963, or roughly half of the total research, development, test and engineering budget, he said.

The program definition phase should be a short, controlled effort, just large, long and intensive enough to provide detailed mutual understanding and agreement between the government and the contractor as to what is wanted, how to proceed and what it will cost in money and time, Gardner told the conference.

"Program definition should not be initiated until the government has firmly decided what capabilities it wants to achieve and, to a first approximation, that it is prepared to pay the price," he said. Program definition is most effective, Gardner said, when done in a competitive environment, but the advantages are lost if there are long time gaps between completion of the program definition phase, the government's decision to proceed and the awarding of a definitized contract.

Decision Delays

Gardner said that program definition contracts should not be used as a means of postponing difficult government decisions, or to decide what kind of military capability is required. The latter is an appropriate subject for study contracts, but is incompatible with the basic objectives of a program definition study. Such studies should precede the program definition phase, according to Gardner.

The Pentagon official said that the Defense Dept recently has instructed the services to establish for every applied engineering program of major size a single project manager who is to be given both technical and financial responsibility for the program.

Dominant Roles

The unreliability and lack of combat suitability of many postwar weapon systems is the result of the greatly telescoped time between discovery of new knowledge in the laboratory and its application in the field. As a result, technologists with relatively little feel for the combat environment have played dominant roles in developing complex weapon systems, while military officers with inadequate technical experience often have been over enthusiastic about the military potential of undemonstrated, premature technical developments, he said.

PERT Automated

Preparation of PERT management network charts can be accomplished automatically using a technique called PERT-NAP (network automatic plotting) developed by North American Aviation.

The technique uses a computer and a cathode ray display device built by General Dynamics Corp. Schedule changes fed into a computer on one day are converted to updated networks by the next morning, NAA says.

Minimum operational PERT-NAP is slated to be working by July with full system implemented for company-wide uses by early next year.

United Nations Group Fails to Gain Accord on Space Use Rules

By Ward Wright

United Nations, N. Y.—Second meeting of the United Nations' legal subcommittee working to formulate general principles for the peaceful uses of outer space ended in failure early this month despite some progress by the subcommittee.

Subcommittee failed to recommend even non controversial principles upon which there had been general agreement (AW Apr. 22, p. 29).

Austria's subcommittee representative Dr Rnbert Marshik, summed up results of the second meeting as "what was lacking was not agreement, but the will to record it."

Meetings Summary

After 13 meetings, the legal subcommittee adopted a short summary of results describing the second session as "a very useful and constructive exchange nf views " with the notations that some delegations favored in international treaty type document and others a United Nations' General Assembly resolution.

Summary listed proposed general principles for peaceful space use as falling into three categories:

- Those where there were no differences in views.
- Those in which there has been a reapproachment of views.
- Those in which differences of view remain.

Report recommended that the legal subcommittee delegations continue to try to reach agreement informally before the next meeting of the UN Space Committee in September.

Second Session

At the outset of the second session, it was hoped among non-Soviet bloc delegations that non-controversial general principles could be adopted while work continued on principles capable of being adjusted to differing points of view.

General principles not likely to be resolved quickly, such as a prohibition of reconnaissance satellites would be left to later sessions.

Issues considered non-controversial and ready for adoption by the subcommittee include principle of freedom for exploration and use of outer space by all states equally under international law, immunity of celestial bodies from national appropriation, applicability of international law, including the UN Charter to relations among states in outer space, retention by the launching authority of jurisdiction over and ownership of space vehicles and their personnel, and on liability for injury or damage that might be caused by space vehicle accidents.

Issues considered capable of agreement through adjustment of points of view consist primarily of a new willingness of some delegations to enter into multilateral treaties on the subjects of assistance rescue and return of astronauts and space vehicles and liability for space vehicle accidents.

Other issues in this category concern the matter of private space ventures and means of appropriate international meeting concerning problems of interference and contamination of outer space.

Issues not likely to be quickly resolved include space reconnaissance and prohibition of war propaganda in outer space.

Feeling among UN observers is that failure to adopt non-controversial principles stemmed largely from the Soviet Union's stand on two points:

- Insistence that its 11-point package proposal submitted Apr. 16 be adopted in entirety.
- Demand, for the first time, that these principles be drawn up into a treaty to be ratified by individual states.

Soviet Attitude

Soviet attitude was that in their "new" 11-point proposal they had made concessions that should be acceptable to all.

However most subcommittee representatives regarded the Russians' concessions as minor.

Soviet feeling was that before details of individual principles could be worked out, a set of general principles would have to be adopted since the issues of peaceful use of outer space are interrelated.

The other stumbling block ratification of an international treaty incorporating these principles as opposed to having them carried by UN General Assembly resolution, was seen by some observers as a means of shifting the blame to the West for failure to adopt a set of principles which the Soviets knew were unacceptable at the time they were formulated.

Soviets contend that an international treaty is necessary to make space law binding.

Non Soviet bloc countries felt that a General Assembly resolution is binding and not subject to the delays and difficulties inherent in ratification of an international treaty.

SAFETY

CAB Accident Investigation Report:

Undetected Prop Reversal Blamed In Fatal FAA Constellation Crash

A Lockheed Constellation, Model L 749A, N 116A, owned by the United States government and operated by the Federal Aviation Agency, crashed following a local training flight at Topham Field, Canton Island, Apr. 26, 1962, at 1213 local time. All four FAA crew members were fatally injured. One of the two passengers, not an FAA employee, was also fatally injured. The other, an FAA physician, was seriously injured. The aircraft was destroyed.

The purpose of the flight was to train the copilot in various maneuvers and flight configurations prior to being tested for an Airline Transport Pilot Rating and to train a flight maintenance technician as a flight engineer.

The probable cause of the accident was loss of control during an attempted go-around following initial touchdown as the result of an undetected reversal of No. 4 propeller.

Investigation

A Lockheed Constellation, Model L 749A, N 116A, owned by the United States Government and operated by the Federal Aviation Agency, crashed following a local training flight at Topham Field, Canton Island, Apr. 26, 1962, at 1213 local time[1]. All four FAA crew members were fatally injured. One of the two passengers, not an FAA employee, was also fatally injured. The other, an FAA physician, was seriously injured. The aircraft was destroyed.

The last flight of FAA Constellation N 116A prior to the accident was on Apr. 25. That flight was from Honolulu, Hawaii, to Canton Island, and was operated as FAA Logistic Flight 62 53 carrying passengers and freight. Before departure from Honolulu there was a brief delay caused by the changing of the rear spark plug of No. 15 cylinder of No. 4 engine. Otherwise the flight was routine, and of about eight hours duration with arrival at Topham Field, Canton Island, at 1855 April 25. The crew consisted of Pilot in Command Julius J. Terranova, Copilot Herbert C. Fielding, Flight Engineer Harry E. Johnson, Navigator Robert R. Rassmussen, and Flight Maintenance Technician Paul L. Garriott, Jr. Flight Engineer Lloyd Z. Young was deadheading.

A local training flight at Canton Island on Apr. 26 had been authorized by FAA's Chief of Aircraft Operations for the Pacific Region. For this flight the crew consisted of Cap. Julius J. Terranova, a designated check pilot; Copilot Herbert C. Fielding; Flight Engineer Lloyd Z. Young; and Flight Maintenance Technician Paul L. Garriott, Jr. There were two passengers. Dr. John B. Miller, FAA resident physician of Canton Island and Archi Tabonga, an employee of the Standard Oil Co. at Canton Island. The purpose of the flight was to train Copilot Fielding for his Airline Transport Pilot Certificate flight test and also to train Flight Maintenance Technician Garriott as a flight engineer.

Flight Engineer Young assisted by Mr. Johnson, the flight engineer on the previous day's flight, preflighted the aircraft and supervised the refueling. At 0855, Capt. Terranova filed a local VFR (Visual Flight Rules) flight plan with the IFSS (International Flight Service Station) at Canton estimating the flight time as about four hours. Crew and passengers then boarded the aircraft, with Copilot Fielding occupying the left pilot seat, Capt. Terranova the right pilot seat, Mr. Garriott the flight engineer's station, and Flight Engineer Young standing adjacent to Mr. Garriott. Dr. Miller sat in the observer's seat behind the left pilot seat, and Mr. Tabonga was in the first seat on the left side of the passenger compartment. During the investigation no weight and balance figures could be found; however, Flight Engineer Johnson later estimated the aircraft's gross weight at 88,156 lb. The maximum allowable for takeoff was 107,000 lb.

The engines were started with Mr. Johnson acting as fireguard, and at 0900 the flight contacted Canton IFSS advising it would be taxiing to the runway in about 10 min.

After run-up the aircraft took off from runway 9 reporting off at 0914 to Canton IFSS. As observed from the ground by Flight Engineer Johnson and others, the aircraft stayed in the airport traffic pattern and made several approaches and landings with various flap configurations, some employing propeller reversing after touchdown. The first landing was to a full stop and appeared to be with 50% flap. The aircraft was then taxied back and immediately taken off again. The next approach appeared to be with full flaps. A go-around was started some 300 ft. over the threshold and the aircraft was flown level over the runway with flaps down. On the next landing which was to a full stop, the final approach appeared long, flat, and fast.

The next takeoff was with flaps up. The aircraft left the traffic pattern and was climbed to altitude for the purpose of conducting emergency procedures training.

Surviving passenger Dr. Miller indicated that these procedures included the feathering and simulated feathering of propellers and the simulation of hydraulic and elec-

[1] All times herein are local (165th meridian) based on the 24-hr clock.

it system failure. During this period the crew of N 116A contacted Canton ITSS several times. At 1042 they advised being 10 mi. first at 9,000 ft. At 1108 they reported over Canton at 6,500 ft. and stated that operations were normal. At 1142 they reported four miles out, requested traffic information and advised their intention of making a pass over the airport. Shortly thereafter the aircraft passed over the airport from north to south at an altitude of about 500 ft. and then continued out over water where it circled several times. The aircraft was then climbed to traffic pattern altitude and entered a left downwind leg. At this time, according to Dr. Ahlin, Flight Engineer Young took over the engineer's panel and Mr. Garriott stood behind Young. Mr. Fabonga stood in the doorway of the flight deck.

At 1210 N 116A contacted Canton ITSS and requested the current altimeter setting, which was given as 29.86. N 116A acknowledged. This was the last radio contact with the aircraft, during none of the radio contacts had any mechanical difficulty been mentioned.

N 116A was observed to make an approach for landing.

Following touchdown the aircraft rolled 239 ft. on the right main landing gear with the right wing continuing to drop. The aircraft then lifted off in a nose high and right wing down attitude, and the right wing tip struck the ground at the right edge of the runway. This crushed the right wing tip as well as the outboard portion of the wing and the right aileron. The aircraft at the time was banked sharply to the right and the nose was high. With the angle of bank increasing, the turn continued with the right wing scraping and being shredded by coral. An 18 in. high coral ridge was struck, causing further breakup of the wing. The angle of bank continued to steepen, the aircraft cartwheeled coming to rest 220 ft. off shore in water about three feet deep. All engines broke free. There was no fire either before or after impact.

The weather at the time of the accident was scattered clouds at 2,000 ft., visibility more than 15 mi., temperature 86°F, dew point 73F, wind east northeast 6 kt., altimeter 29.86.

The first identifiable tire marks on the runway were 650 ft. past the threshold of runway 9. This runway is 6,000 ft. long and 150 ft. wide. The touchdown was on the two right main wheels only, indicating a right wing low attitude. According to the marks the outboard right tire touched before the inboard right tire. This touchdown was 20 ft. to the right of the centerline of the runway, indicating the centerline of the fuselage was six feet to the right of the centerline of the runway. This mark was solid for 17 ft., then very light with intermittent markings for the next 95 ft. At this point a solid mark made by the outboard tire of the right landing gear started 29 ft. to the right of the runway centerline and ended 127 ft. down the runway, 38 ft. from the centerline of the runway. The average heading of this mark was 097° deg., or 7 deg. from the runway heading. The aircraft became airborne at this point and there were no further tire marks.

Two hundred thirty six feet from the last tire mark and 24 ft. off the right edge of the runway, the wing tip first scraped the coral terrain as evidenced by impact marks. Four feet from this first impact the right wing struck a taxiway light located 18 ft. from the right edge of the runway. At this point the right wing tip and a portion of the right wing outer panel failed upward, leaving skid marks about seven feet wide across a taxiway and adjacent terrain for 475 ft. Here the right wing tip struck a crushed coral ridge 18 in. in height and approximately 170 ft. from the right edge of the runway. The average heading of the skid mark as it crossed the taxiway was 102 deg. Sixty six feet from the coral ridge a second ridge one foot high was contacted. The average heading of the skid mark between these two ridges was 127 deg. Numerous small pieces of de-icer boot material were found along the path between these ridges. Beyond the second ridge were found a wing leading edge former with a small portion of skin attached, a 20 in. section of leading edge skin with stringer attached and a fuel tank vent from No. 3A tank.

These items were 37, 60 and 146 ft. respectively along the flightpath from the second ridge.

A trail of fragmented parts and debris led to the edge of the water and to the main wreckage some 220 ft. off shore. This main wreckage consisted of a large portion of the fuselage and sizable portions of both wings. These parts were on a heading of 50 deg. and were resting on a coral shelf. The empennage was broken from the fuselage and was found 40 ft. aft of

the fuselage break on a heading of 35 deg.

A total of 16 persons on the ground saw or heard various phases of the final approach, touchdown and crash. A number of their statements indicate that the final approach was higher and steeper than usual with flaps extended 100%. One, a weather observer, stated in effect that the aircraft touched down on both main landing gears some 300 ft. past the runway threshold. Another, Flight Engineer Johnson, observed the right wing to be slightly down and the nose to be down just before touchdown which he thought was farther down the runway. Some witnesses heard a pronounced increase in engine noise when the aircraft swerved from the runway.

Much of the forward portion of the aircraft was literally ground away by sharp coral. However, the airframe proper, its control systems, other aircraft systems, the instrumentation, the engines and the propellers were examined. There was no evidence of failure of the airframe nor of the control systems. Readings of instruments, engine controls, and tab settings, which could be obtained, yielded nothing that could be directly related to the accident. The flap handle was in the "up" position. The flap control mechanism indicated the flaps were in transit upward at approximately 60% at time of impact.

The cockpit aileron and rudder boost control levers as well as their related control valves were found in the "off" position.

The maintenance records of the aircraft indicated both proper and current maintenance.

The engine examination, which included complete disassembly, was conducted under Board supervision at Los Angeles where complete facilities were available. There was no sign of operational distress in any of the four engines nor did the maintenance histories of the engines suggest any items that could logically be linked to this accident.

Propeller Pitch

Examination of the four propellers indicated that the blade angles at the time of impact were 15 deg. positive, 15 deg. positive, 23 deg. positive and 20 deg. negative for Nos. 1, 2, 3 and 4 respectively. The low pitch stop is at 15 deg. positive and the reverse pitch stop is at 20 deg. negative. Functional tests and disassembly of the pitch changing mechanism of the four propellers did not reveal any irregularities. Functional tests of the four governors were satisfactory. Two of the governors were checked for engine rpm. settings with 2,260 and 2,300 indicated. The above work was accomplished at Honolulu. Subsequently the No. 4 governor was again functionally tested and disassembled at Los Angeles. The test was satisfactory. The only discrepancy found during examination following disassembly was scoring and pitting on the low pressure relief valve. Propeller repair specialists described the extent of this scoring and pitting as "excessive" considering the relatively low operational time of 352 hr. since the last overhaul. The cause of the scoring and pitting could not be established.

The No. 4 governor had been overhauled and all applicable Service Bulletins and Airworthiness Directives complied with in June 1960. The governor was retained in stock as a spare unit until July, 1961, at which time it was again disassembled, inspected, latest modifications incorporated, reassembled and functionally tested. The low pressure relief valve was not replaced and reportedly was in good condition at this time.

Autopsies were performed on the bodies of the crew members. Only one significant fact was revealed. Flight Engineer Young had recently ingested a significant amount of a barbiturate. His tissues contained therapeutic quantities of an unidentified barbiturate—with physical properties similar to butabarbital—which would be compatible with his having taken a 100 mg. dose of a medium or long-acting barbiturate three times a day for a prolonged period. This same tissue level could have been achieved in other ways such as taking four or five 100 mg. tablets a few hours before death, or five to ten tablets 10 hr. before death.

Barbiturate Usage

The Administrator had elected to conduct flight operations of this aircraft in accordance with Parts 20, 43, and 60 of the Civil Air Regulations except for certain special deviations. Section 43.45 of Part 43 of the Civil Air Regulations prohibits any person from serving as a crew member in civil aircraft while using any drug which affects his faculties in a manner contrary to safety. However, a deviation from this provision is found in the Administrator's Manual of Procedures which governs the operation of this flight in that it proscribes the use of barbiturates by crew members within twelve hours prior to flight.

The sequence of events prior to and during the accident was established largely through details provided by the survivor, Dr. Miller. He was seriously injured and was initially able to recall only the general activities, operations, procedures and maneuvers prior to the final touchdown of N 116A. He was unable at first, to recall details prior to and immediately after the accident other than that the touchdown was normal, the aircraft gradually veered to the right, and the Pilot-in-Command, Capt. Terranova, shouted "   frozen!", and reached far to the left from his right seat across the pedestal to some undetermined control. The copilot in the left seat had both hands on the control wheel, according to Dr. Miller.

Survivor Questioned

Dr. Miller, a government physician, was eager to help in the investigation of this accident. At the suggestion of a Board investigator he agreed to be questioned while under the influence of sodium amytal, a drug used to prompt memory recall. The method or technique, is known as narcosynthesis and is sometimes used by physicians to help patients release suppressed information.

Accordingly on May 11, 1962, Dr. Miller voluntarily submitted to a medically supervised interview under narcosynthesis with a Board investigator present. Lt. Colonel Paul Yessler, M.C., U.S.A., Chief, Neuropsychiatric Division at Tripler Army Hospital, Honolulu, administered the drug. At this time Dr. Miller recalled many of the details of the flight including the words which Capt. Terranova shouted as the aircraft veered to the right on landing. Con-

trols frozen , and Ailerons frozen Dr Miller also remembered that at approximately the same time, Capt Terranova reached for the aileron and rudder boost control levers and pulled them to the full position On May 12 1962 a tape recording of the interview was played back for Dr Miller, at which time recall of these details was verified This was the first use of narcosynthesis interview technique in the Board in connection with the investigation of an aircraft accident

Aircraft and powerplant maintenance and the state of the weather cannot demonstrably be linked to the cause of this accident

Investigation of the airframe systems and powerplants revealed the following three items which cannot be accepted as normal and will be specifically considered in this analysis, namely

- No 4 propeller in reverse pitch (—20 degrees)
- No 4 propeller governor low pitch relief valve pitted and scored
- Aileron and rudder boost off

Otherwise, no evidence of a suspect nature was disclosed by the investigation of the airframe systems, and powerplants

The landing culminating in the accident was to have apparently been the last for the day Maneuvers, and their sequences which were being practiced prior to the final landing, are not known precisely However according to the survivor they included a considerable number and variety of simulated emergency conditions including a feathered propeller or propellers in conjunction with other simulated difficulties The use of propeller reversing during landings was established

The reportedly higher and steeper than usual final approach with flaps extended 100% is not considered unusual especially during the conduct of a training flight The approach configuration and path are not considered pertinent to the probable cause of the accident or indicative of difficulties being encountered

Discussion of the initial touchdown of the aircraft on the right main landing gear and its subsequent attitude and path of travel cannot be divorced from considerations of the No 4 propeller which was found in full reverse pitch Apparently the approach was essentially normal until just prior to touchdown The propeller operating during approach with an ineffective low pitch stop constitutes a very logical cause for the landing events as described

As power and airspeed are progressively reduced, propeller pitch decreases to maintain the selected rpm until the low pitch stop is reached Normally, any further reduction in airspeed and/or power is reflected by a reduction in rpm In the event the low pitch stop is ineffective blade angle is further reduced and at least initially the selected rpm is maintained This situation would be most readily evident to the crew by an rpm decrease on three tachometers and one No 4 would remain at the selected reading Change in thrust as sensed by the pilot at the controls would be relatively minor and probably would go unnoticed during the phase under discussion.

As the airspeed and/or power was further reduced and probably at the time power was reduced to start the flare, energy input to the propeller would decrease such that the selected rpm would not be maintained and the propeller blade angle would abruptly decrease with an appreciable rpm decrease, and would move into the reverse pitch regime and continue to full reverse As the propeller moved toward full reverse, the reverse pitch indicating light located on the pilot's panel would come on This light comes on about 5 deg before full reverse pitch is reached

Accompanying this blade angle change would be an abrupt and very substantial increase in drag and some reduction of right wing lift It is concluded this is what occurred because it is not only compatible with the touchdown attitude but with the physical evidence as well

Information as to specific power and specific airspeed at any particular time along the final approach path is lacking However to provide some appreciation of the parameters involved the airspeeds, rpm

Bell Tests New GEM

Bell Aerosystems' "Carabao" ground-effect machine, developed for the commercial market, recently began tests at Bell's new GEM test base on Lake Erie at Buffalo. Craft uses three cells fed by a single lift fan driven by a 60-hp Franklin aircraft engine. Propulsive thrust is supplied by a 150-hp Lycoming aircraft engine driving a variable pitch, 6-ft propeller Vehicle's gross weight is 2,900 lb Measurements are: length, 15.7 ft., width, 16 ft., height, 10 ft Top speed is 60 mph

and powers which result in the propeller governing at the 15 deg low pitch stop, are listed as follows

Revolutions per Minute	Indicated Air Speed	Brake Horsepower
2300	140	147
2300	130	294
2300	120	426
2300	110	528
2300	100	646
2300	90	720

A reduction of IAS and/or BHP, with rpm remaining constant, causes the propeller blades to go below 15 deg blade angle if the low pitch stop is ineffective. The reportedly steep descent on final approach is compatible with low BHP.

After contact with the runway by only the right gear for 239 ft., during which an application of power was heard, the aircraft lifted off and while turning to the right, the right wing tip contacted the ground. The right turn continued with the right wing dragging. Indications are that the wing flaps were in transit toward the retracted position which, in conjunction with the application of power leads to the conclusion a go around was being attempted. The only logical explanation for this uncontrollable maneuver, compatible with the physical evidence, is that with Nos 1, 2, and 3 propellers in forward thrust and No 4 propeller in reverse thrust, full power was applied during an appreciable period following the initial touchdown.

The possibility that early use and/or misuse of the throttles may have precipitated the accident has been considered. One such possibility considered is that reverse thrust may have been applied before the aircraft was firmly on all landing gears then because of control difficulty forward thrust was applied with No 4 failing to respond. Such an occurrence has been discounted because the short time involved precluded normal reversing and unreversing of the four propellers. Furthermore the throttle arrangement on this aircraft make inadvertent application of reverse thrust most unlikely.

An ineffective low pitch stop is considered the most likely cause of the premature reversal of the No 4 propeller. The timing and sequence of events following initial touchdown are precisely what would be predicted in this event.

As for an explanation there are several possibilities. A false electrical reversing signal would immediately initiate a reversal and would be expected to be random timewise. Special precautions taken to protect the reversing solenoid circuit from false signals have been very effective. This is considered to be the most unlikely of the several possible causes of the unwanted reversal that have been considered.

Timing of the reversal as previously discussed is considered to be very pertinent to this conclusion. Either a governor low pressure relief valve seized in the closed position or a low pitch stop lever assembly servo valve stuck in the open position would render the low pitch stop levers ineffective. Normal propeller response to airspeed and power with either of these malfunctions present would result in propeller response as previously discussed. A propeller feathering and unfeathering in flight would provide the positioning for either of these valves

which in the event of sticking would precipitate the events which are believed to have culminated in the accident.

Although No 4 was not specifically mentioned, the survivor did state simulated emergencies including feathering and unfeathering of propellers were accomplished during the training flight. The physical condition of the low pressure relief valve as found makes it the most likely cause of the unselected reversal. That the fault was not revealed by functional tests is not a compelling reason for eliminating these two possibilities.

Hydraulic Test

It is not unusual for a hydraulic component malfunction to fail to recur when the unit is subsequently checked on a test facility.

This is especially apt to be true if the initial trouble had been caused by contamination in the oil for, under test, clear oil is used and the original contaminant may be displaced immediately.

The Board believes that the accident had its inception when No 4 propeller was in reverse pitch unknown to the crew, during the final approach, and that upon touchdown, directional and attitude control loss was followed by application of power for a go around causing high yawing forces, quickly swerving and banking the aircraft into the ground.

As previously mentioned, a reverse pitch indicating light is located on the pilot's panel which would actuate five degrees prior to the propeller travel to full reverse. In addition this condition could have been detected by the difference in the rpm between the engines by any of the three flight crew members.

It cannot be stated that the flight engineer's failure to detect the rpm change was the result of his use of barbiturates.

It is obvious by Capt. Terranova's action i.e., pulling the aileron rudder boost control "off" and shouting "controls frozen, ailerons frozen," that his reaction to the directional and attitude control difficulty following touchdown was in fact to correct a control malfunction—not a propeller reversal problem. This action further compounded the control difficulties. A jammed aileron because of damage from contact of the right wing with the ground logically accounts for such a diagnosis, although erroneous, by the captain.

Probable Cause

The Board finds that the probable cause of the accident was loss of control during an attempted go-around following initial touchdown as the result of an undetected reversal of the No 4 propeller.

By The Civil Aeronautics Board

Alan S. Boyd, Chairman; Robert T. Murphy, Vice Chairman; Chan Gurney, Member; G. Joseph Minetti, Member; Whitney Gillilland, Member.

The Civil Aeronautics Board was notified of the accident immediately after occurrence.

An investigation was started at once in accordance with the provisions of Title 7 of the Federal Aviation Act of 1958.

Operator

The Federal Aviation Agency, Pacific Region, operated Constellation N 116A which

was owned by the United States government

Flight Personnel

Capt Julius J Terranova, age 38, was employed by the Federal Aviation Agency on May 23, 1959. He possessed an FAA Airline Transport Pilot Certificate, No 238865, and ratings in L-749 and DC-4 type aircraft. He had a total of 5,867 hr, of which 3,911 were in Constellation type aircraft. His last proficiency check was on Sept 6, 1961, and his last en route check was on Feb 11, 1962. His last first-class medical examination was taken in Feb, 1962, with no limitations. On Aug 7, 1961, Capt Terranova was appointed check pilot on L-749 and DC-4 type aircraft.

Copilot Herbert G Fielding, age 45, was employed by the Federal Aviation Agency on Feb 8, 1960. He possessed FAA commercial certificate No 429746, with multi-engine and instrument ratings. He had a total of 8,353 hr, of which 524 were in the Lockheed L-749A. His last first-class medical examination was passed on Apr 19, 1962 with no limitations.

Flight Engineer Lloyd Z Young, age 45, was employed by the Federal Aviation Agency on Mar 7, 1959. He possessed Flight Engineer Certificate No 1196651, and Airframe and Powerplant Mechanic Certificate No 161034. He had a total of over 6,000 hr in Constellation aircraft. His last second-class medical examination was passed in October, 1961.

Student Flight Engineer Paul L Garriott, Jr., age 32, was employed by the Federal Aviation Agency as a Flight Maintenance Technician on July 10, 1961. He possessed Airframe and Powerplant Certificate No 1372514. His last second-class medical examination was passed in June, 1961.

The Aircraft

The aircraft was originally purchased from Lockheed Aircraft Corp, by Eastern Air Lines on Feb 10, 1949, as model No L-749A-79, S/N 2611. It was leased by the United States Government from EAL, and certificated Aug 23, 1960.

The United States government purchased the aircraft June 30, 1961. The aircraft was utilized for logistics purposes and was operated in the FAA's Pacific Region out of Honolulu, Hawaii. It had been flown a total of 1,189.8 hr by the FAA. The aircraft had a total of 41,481.6 hr and 3,968 hr since the last Block 3 overhaul which was accomplished by Eastern Air Lines.

FAA maintenance records indicate that the last preflight check (daily) was performed on N 116A, 11.0 hr prior to Apr 25, 1962. A total of 80.5 hr had been flown since its last numbered check (No 11), which was completed on Mar 29, 1962. FAA maintenance system numbered checks are performed every 120 hr.

The engines were Curtiss-Wright model No 749C18BDH with operational times since overhaul of 91.9 hr, 38.9 hr, 999.6 hr, and 474.3 hr for Nos 1, 2, 3, and 4, respectively.

The propellers were Hamilton Standard model No 43E60-343, blade type 6903B-0. Their operational times since overhaul were 263.9 hr, 2,065.1 hr, 91.9 hr and 2,065.1 hr for Nos 1, 2, 3, and 4, respectively.

WHO'S WHERE

(Continued from page 23)

Changes

Hugh Brady, director Apollo Program, Milwaukee Plants, AC Spark Plug Div., General Motors Corp., Milwaukee, Wis. Also Jack F. Steele, manager of specialized marketing, Milwaukee operations of AC Spark Plug Div.

Ray Raffesberger, chief engineer-Centaur ground support equipment, General Dynamics/Astronautics, San Diego, Calif.

Steve D. Truhan, director-vehicle flight readiness, Douglas Missile & Space Systems Div., Santa Monica, Calif.

George T. Dib, coordinator of space technology, Vitro-Smith Corp., New York, N.Y.

J. W. Miller, director-marketing, Piper Aircraft Corp., Lock Haven, Pa., and W. C. Smith, sales manager.

Ivan F. Weeks, senior staff scientist to the director, Office of Research, San Bernardino (Calif.) Operations of Aerospace Corp. Other San Bernardino Operations appointments: Edward Pepper, director, Nike-Zeus Target Program; Alex Petrovsky, manager, integration engineering, Mobile Mid-Range Ballistic Missile (MMRBM) Program; George C. McKoy, manager, systems analysis and instrumentation, ATHENA Program Office; Thomas R. Hershey, section head, computer systems and operations, Computation and Mathematics Center, Technical Div.

Paul A. Deegan, director of administration, Avco Corp.'s Lycoming Div., Stratford, Conn.

United Aircraft Corp.'s Norden Div., Norwalk, Conn., has announced the following appointments: Carl F. Schaefer, video systems engineering manager; Shu Lee, guidance and control engineering manager; Eugene Tatom, solid state engineering manager; Robert D. Rinehart, component engineering manager; Leo Botwin, radar systems engineering manager; Frank S. Preston, advance engineering manager.

T. Albert DeBacker, director marketing, LFE Electronics, a division of Laboratory For Electronics, Inc., Boston, Mass.

Robert R. Stephens, manager-engineering, Vitro Electronics, a division of Vitro Corp. of America, Silver Spring, Md., and Kenneth B. Boothe, manager-sales.

William G. Weigel, manager, Aerex Commercial Explosives Program, Ordnance Div. of Aerojet-General Corp.'s Downey (Calif.) Plant. Joseph B. Tortorici succeeds Mr. Weigel as customer relations manager of the Ordnance Div.

Hans E. Baumgartner, research engineer, research and development group, Beekman & Whitley, Inc., San Carlos, Calif.

Martin Lyford, process-control applications manager, Commercial Computer Div., Information Systems Group, General Precision, Inc., Burbank, Calif.

Dr. C. Dudley Fitz, chief, Penetration Aids Branch, Directorate for Ballistic Missile Defense, Advanced Research Projects Agency, Washington, D.C.

J. Lynn Helms, assistant general manager, Bendix Corp.'s Systems Div., Ann Arbor.

Henry E. Dralle, director-field engineering services, Burns and Roe, Inc., New York, N.Y.

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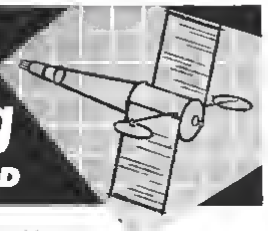

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  - Nuclear Hardened Electronics
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  - Advanced Multiplexing Techniques
  - Information Theory
  - Nuclear Radiation Effects

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LETTERS

McNamara's Teams

I find your recent article (AW Apr 29, p 23) entitled "Pentagon Teams Prepare McNamara on TFX" incredible

It does not seem possible to me that our government has sunk to the depths which this article indicates Is it truly possible that McNamara is spending thousands of the taxpayers dollars to pay a team of experts to work (especially nights and weekends) to justify a stand he has already taken? What happened to all the facts and figures he used to come to this decision?

If this article is really a statement of the facts it can only mean that we are governed by a group who make haphazard choices strictly as their whims dictate and then spend our money in an attempt to justify this choice

EUGENE A PARSONS
Minneapolis, Minn.

Brittle Brilliance

Reference your editorial "The Brittle Brilliance" (AW Apr 15, p 21)

It is sad that an individual of your intelligence would stoop so low in your attempts to degrade the Kennedy Administration That you should be so well informed and possess the genius of having better judgment than the Administration, on all the problem areas which you mention, is incredible That you should be so unscrupulous as to attempt to sell such distortions and falsehoods to your readers is even more astounding

As one of the most ardent supporters of this most capable Administration, I wonder how you can flounder to the extent that your smart-aleck antics cause you to completely miss the incredible trail of political, technical and moral excellence of this Administration

JEROME V. RAY
Justin, Tex.

It won't take much of your time to read what I have to say about your editorial in the issue of Apr 15 I believe it's the best comment on the Administration I have ever read and if given the opportunity would not change a comma

E F MULLIGAN
President
The Jones Metal Products Co.
West Lafayette, Ohio

Congratulations on your editorial in the Apr 15 issue More of this truth telling needs to be published—keep it up!

PETER C CAMERON
Washington, D C

Your editorial "The Brittle Brilliance" (and others, for that fact) should be made available to every GOP group and club in the country for reproduction and mass distribution

I fear it will take more than one year to get the controlling vote to the editorial pages of publications who are analytical in their criticism of the present Administration, and more than a year for these publications to front page such editorials

W W NEUBAUER
Los Angeles, Calif

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

For about ten years I have been a subscriber and regular reader of AVIATION WEEK During this time I have always found the magazine informative and interesting but never before reading your Apr 15 editorial "The Brittle Brilliance" was I tempted to speak up

For that editorial you have my most sincere congratulations and respect Your comments indicate a keen insight and understanding of the situation as well as an unusual degree of courage

LEONARD J WILLIAMS
Washington, D C.

Your editorial in the AVIATION WEEK Apr 15 issue is the most clear and concise indictment of the Kennedy Administration failures that I have read

Please let me know if it is possible to buy reprints of this editorial If you do not have reprints available, please let me know if I can have permission to reproduce the editorial for the purpose of mailing to members of Congress, other editors and friends

HARLEY TOMPKINS
Orlando, Fla

May I congratulate you in general for your fine magazine and in particular for your editorial "The Brittle Brilliance"

JEROME L NEWMAN
Seattle, Wash.

U. S. Space Effort

I am happy to see that somebody is enumerating arguments for the continuance of the Apollo lunar program at its current pace As AVIATION WEEK mentioned in its editorial of Apr 29 (Apollo and Its Critics), there are, indeed, many vital reasons why America must pursue the exploration of space at a maximum pace, but as yet few attempts have been made to disseminate these reasons to the American public AW is an important organ of technology, but it doesn't often reach the layman Popular journals continue to emphasize the hazards of manned space flight, the astronomical costs, the ingenious engineering applications, and the exciting "spaceball game" with the Soviets These are all very interesting and, when accompanied by attractive pictures, they make entertaining reading But this sensationalistic approach hardly serves to win public support for an endeavor which continues to wear an exotic halo as the somewhat curious child prodigy of science and technology

As much as we hate to admit it, our manned space program is funded as a product of reaction instead of action Many congressmen and other public leaders must still be shaken by Russian space feats or inspired by the exploits of a selfless and courageous astronaut before they will drop their demands for a selective cheese paring of the NASA budget

Let us pray, therefore, that Gordon Cooper goes at least thirty orbits, that Lunik V lands its payload on the moon with feather like softness and that the anticipated eight day Vostok flight is replete with the appropriate forebodings Otherwise the space program may have to wait until Saturn orbits its nine tons of good drinking water in September for congressional inspiration and popular acclaim

JIM HUTCHINSON
Atlanta, Ga.

Ranger Sterilization

In reference to the article entitled "Ranger Sterilization" (AW Apr 29, p 26), I would like to make some corrective comments concerning the statements by Dr. Joseph Shea of NASA

If mission objectives establish sterilization as a spacecraft design requirement, then that vehicle is improperly designed if it is not compatible with sterilization techniques, since it is then not compatible with its own mission requirements The question is Do the mission objectives require sterilization to assure success?

In the case of Ranger, it has been NASA policy to maintain a low level of contamination on the moon to protect subsequent scientific samples (among other reasons)

Ranger internal sterilization was obtained to a degree, by heat, with waivers granted to preclude heating to sterilize any heat sensitive component Surface sterilization was accomplished with a sterilant gas

Since all known tests indicate that gaseous surface sterilization does not affect reliability, Ranger problems were definitely not due to sterilization but, instead, were ordinary design problems unrelated to the inclusion of this requirement It is, therefore, grossly unrealistic to blame sterilization for the Ranger failures

For the Apollo project, internal sterilization was never proposed nor implied, since this is a manned soft landing which would obviously contaminate in case of a severe impact Simple hospital aseptic procedures have been proposed, with prelaunch gaseous sterilization of space suits which essentially form the entry lock in the stored position Purpose of the proposed aseptic measures on Apollo were to permit initial biological and chemical sampling to be effected aseptically Development of these techniques and equipment is essential to manned planetary exploration

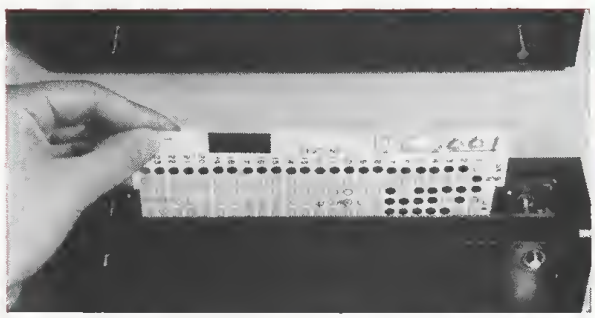
A M NOWITZKY, Head
Spacecraft Sterilization Systems
Lockheed Missiles and Space Co.
Sunnyvale, Calif

4

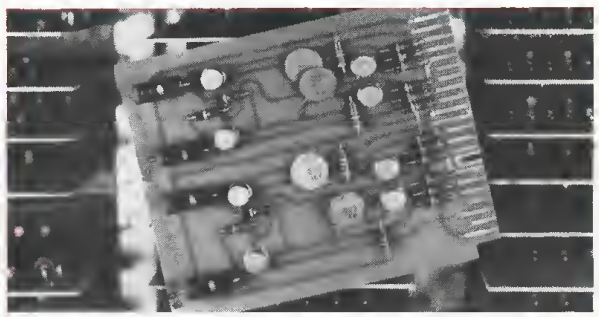
things to look for in semiconductor testers (and where to find them)

Capacity. Economical volume inspection of transistors, diodes, zener diodes and microcircuits is made possible by speed and versatility—key features of all Fairchild testers. An example: the Fairchild Series 100 can make over 75,000 go/no-go decisions per hour.

Display. Fairchild equipment is available with direct digital readout, go/no-go indication and a variety of data logging outputs. The Series 900, for instance, features direct digital display and can drive almost any type of recorder—typewriter, printer or tape punch.



Operational Ease. Simple card programming, standard in many Fairchild testers, makes it possible to change tests or test conditions in minutes. Non-technical personnel can learn to operate any model in Fairchild's line of test equipment in a matter of hours.



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